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AN ANALYSIS OF GEOGRAPHIC VARIATION IN MICE OF THE PEROMYSCUS POLIONOTUS GROUP FROM FLORIDA AND ALABAMA

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[*Plates 15–18*]

INTRODUCTION

For more than twelve years, the writer has been engaged in a study of geographic races of mice of the genus *Peromyscus*. Hitherto, various subspecies of *Peromyscus maniculatus* have furnished material for the greater part of these investigations, and the territory covered has been restricted to California and northern Arizona. The present paper details some of the preliminary results of an extension of these activities to certain parts of Florida and Alabama, where material has been found which promises to yield more valuable returns than any which have thus far been reported.

In previous papers, I have presented results bearing upon geographic variation, statistically considered, upon the relations between certain characters of the animals and certain features of the environment, upon the inheritance of racial and individual characteristics, and various other matters. The present communication will be limited to distributional and statistical studies, based upon the "wild" material. I must leave to future papers any report upon the breeding experiments which have been conducted during the past two years, and which are still in progress. I shall state, however, that each of the possible crosses has been made among the three strongly marked geographic races here considered, while F_2 and F_3 generations and back-crosses of the first and second degree have likewise been reared in fairly adequate numbers.

I may add that the evidences of Mendelian segregation, as regards the subspecific color differences, are obvious, and indeed striking, a situation not met with in my earlier hybridization experiments with *Peromyscus*. By this I do not, of course, mean to imply that the second hybrid generation consists of individuals of the two pure subspecific types, in a ratio of 3:1, or indeed in any ratio. The differences between two subspecies, in respect to coat color alone, appear to depend upon a number of genetic factors, which segregate independently of one another. Nevertheless, individuals indistinguishable in color characters from one or another of the parent races have already been recovered, even in rather limited series of F_2 hybrids and back-crosses. The number of factor differences can not, in such cases, be great, and indeed there seems to be a fair chance of my being able to determine this number approximately in some cases. I shall defer comment upon the revision which has proved to be necessary in certain views previously expressed by me upon the inheritance of subspecific characters.

The chief motives for my selection of the geographic races here considered were two-fold: (1) To investigate what appeared to be a rather spectacular case of adaptive coloration in a mammal; and (2) to ascertain, if possible, the nature and amount of the genetic change which was undergone by this highly modified race or species in the course of its recent evolution from a parent form that can be identified with tolerable certainty. Furthermore, a careful study of this material seems now to be almost an emergency measure, in view of the orgy of land speculation which prevails at present in Florida, and which promises to speedily upset natural conditions throughout most of the state.

For an account of the *Peromyscus polionotus* group of mice, the reader is referred to Osgood's monograph on the genus *Peromyscus*,[1] to A. H. Howell's paper in which he describes *P. leucocephalus*,[2] and to the latter writer's Biological Survey of Alabama.[3] They are all small mice, when compared with most other members of the genus, and are restricted, so far as known, to Alabama, Georgia and Florida (fig. 1). Osgood regards them as being closely allied to the almost ubiquitous North American species *P. maniculatus*, though I find that it is almost impossible to obtain hybrids between these two.[4]

[1] U. S. Biological Survey, North American Fauna, no. 28, 1909.

[2] Journal of Mammalogy, vol. 1, Nov., 1920.

[3] U. S. Biological Survey, North American Fauna, no. 45, 1921.

[4] Numerous matings between individuals of known fertility have yielded but a single hybrid, this resulting from a mating of *P. maniculatus sonoriensis* and *P. polionotus leucocephalus*.

Howell's map (fig. 1) indicates the known distribution of six recognized subspecies, including the form *leucocephalus*, which he discovered in 1920, and described as a new species. The most wide-ranging of

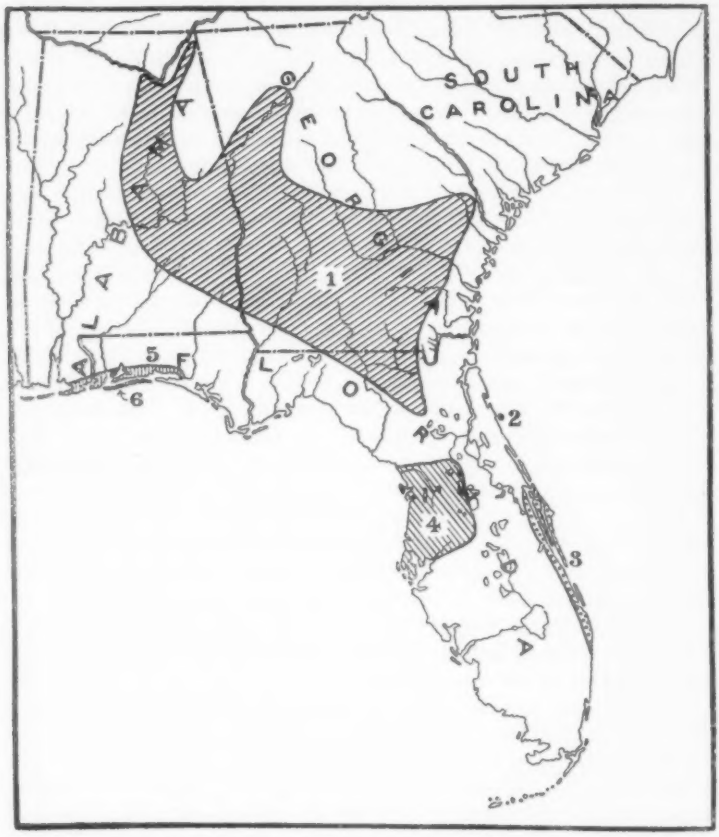

FIG. 1. PROVISIONAL MAP OF THE DISTRIBUTION OF MICE OF THE PEROMYSCUS POLIONOTUS GROUP (AFTER HOWELL)

these races is seen to be the dark form *P. polionotus polionotus* (Wagner). This is likewise the most "primitive," in the sense that its pelage presents most nearly the average condition of the genus, and a dark

dorsal stripe is present throughout the entire length of the tail. The other five forms are pale in color and are mainly restricted to sandy areas near the ocean. They exhibit, in a high degree, the modifications which characterize beach-mice in various other localities. "The color of the underparts [of these Florida races]—white to the roots of the hairs—is unique within the genus with one exception" (Osgood). While it would be unwarranted, without more complete data, to regard the more typical form, *polionotus*, as being ancestral to all the other members of this group, it seems safe to assume that it approximates the ancestral condition more closely than any of the others.

My own studies have thus far been restricted to the subspecies *polionotus*, *albifrons* and *leucocephalus*. It was *leucocephalus* which first aroused my interest in this group. In various previous papers,[5] I have set forth the probability that the pale color of desert mice, and of desert mammals and birds in general, did not arise primarily as an adaptation for concealment, but as a physico-chemical effect of the special atmospheric conditions of arid regions. The arguments which I have employed need not be repeated here. I still regard them as valid. From the first, however, I was aware of the existence of pale races of mice, occupying beaches in various localities, under circumstances which would make it difficult to invoke atmospheric conditions as an explanation. But until rather recently, no case had come to my attention in which the depigmentation of these beach forms had been extreme. It was possible for me to suggest[6] that the modification had been due to the same sort of *physiological aridity* which is held accountable for the xerophytic characters of many beach-dwelling plants. But the paper of Howell (1920), and a subsequent inspection of the specimens collected by him, made me realize that such an explanation was untenable, in one case at least.

Howell's new beach-mouse was collected on Santa Rosa Island, a detached reef of extremely white sand, skirting the coast of northwestern Florida. This race is considerably paler than any desert mammal known to me, and indeed, throughout the greater portion of its pelage, is pure white. Furthermore, the pigmented area of the hair displays much less brown or yellow than that of the familiar pale races of desert mice, but is more nearly neutral gray in appearance. Its occurrence in a region of high rainfall and high atmospheric humidity makes it even less likely that we have to do here with the effects of aridity, in any

[5] Journal of Mammalogy, May, 1921; May, 1924; Ecology, Oct., 1925.
[6] Ecology, Oct., 1925.

sense of that word. The conventional "protective coloration" hypothesis must be admitted to be far more credible in the present instance. (See, however, p. 158.)

It must be insisted, however, that we can not apply any single interpretation to all cases of mammalian coloration. The color of the animal may or may not favor its concealment, and in those cases where it does so, the result may be supposed to have come about either through the more or less direct influence of environmental conditions, or through the selection of germinal variations which arose without any special relation to the peculiarities of the environment. In the case of the Santa Rosa Island beach-mouse, it seems likely that the *appearance* of the background (through selection or otherwise) has been an important factor in bringing about the peculiarities of its pelage. In the case of most desert mammals and birds, I still regard this as highly questionable.

As Howell has pointed out, this highly aberrant race of mice occurs in close proximity to its near relative, *albifrons*, of the neighboring coast. The strait separating Santa Rosa Island from the mainland, is in places, only a quarter of a mile wide. Yet the two races are conspicuously different in appearance and, so far as known, each keeps strictly to its own side of the strait. The differentiation of this well-marked island type has been rendered possible by the physical barrier to interbreeding presented by Santa Rosa Sound.

If any inferences at all are justifiable regarding organic relationships, the assumption seems safe that *albifrons* represents the parent stock from which *leucocephalus* was derived.[7] It is also probable that Santa Rosa Island is geologically of very recent origin, arising as a sand reef, thrown up by wave action, and not as a detached portion of the mainland.[8]

Here then we have what would seem to be unique material for genetic study,—two subspecies (or species?), differing rather widely from one

[7] Such a statement does not necessarily imply that the former race remained absolutely stable throughout the period during which the latter was differentiating.

[8] Dr. T. W. Vaughan and Dr. C. W. Cooke (in a letter to Dr. Vaughan) agree in this belief, though neither of these geologists has visited the locality. Dr. Vaughan thinks it probable that this island has had an origin subsequent to the disappearance of the ice sheet at the close of the last Glacial Epoch, with the consequent change of ocean level. The antiquity of this event is variously estimated at from 10,000 to 35,000 years, while Santa Rosa Island may, of course, be more recent than the lowest of these estimates.

another in several quite tangible characters, one of the two, in all probability, being derived from the other in very recent geological times, and being modified in obvious relationship to certain physical features of the environment. Add to this the occurrence, at no great distance, of another quite distinct race, *polionotus*, which probably retains fairly closely the ancestral color characters of the species. Past experience pointed to the likelihood that these various races would prove to be perfectly fertile inter se.[9]

Genetic studies would not be likely to throw much light upon the question of how the color of this animal's hair became assimilated to that of its environment, but they might be expected to indicate the probable nature and magnitude of the genetic changes which were undergone by the colony of *P. polionotus albifrons* which chanced to be marooned on Santa Rosa Island. What sort of transitional stages, we may ask, bridged the present gap between the one subspecies and the other? Possibly there were none. Perhaps the change was abrupt. Or it may be that the change was very gradual, so gradual that the steps would have been entirely inappreciable to an onlooker.

In the spring of 1924, it became possible for me to make the field trip necessary for the collection of this material. Trapping was commenced on Santa Rosa Island, opposite Camp Walton, Florida, on May 19, and was discontinued on St. George Island, near Apalachicola, on July 4. In the meantime, collecting had been carried on in the following principal localities: (1) Santa Rosa Island, at points throughout the eastern eight or ten miles of its length; (2) the mainland bordering Choctawhatchee Bay, at two different points; (3) the mainland, fronting on the Gulf of Mexico, east of the eastern end of Santa Rosa Island; (4) a long incompletely detached reef, likewise fronting on the Gulf, and extending westward from the mouth of Pensacola Bay to the Mouth of Perdido Bay; (5) Ono Island, near the mouth of Perdido Bay; (6) St. George Island, near Apalachicola; (7) a farm, near Autaugaville, in central Alabama.[10]

[9] That is, as fertile as any *Peromyscus* mated in captivity. As I have frequently stated in the past, there is nearly always a considerable degree of sterility resulting from the conditions of cage life.

[10] For helpful information relative to several of these localities, I am indebted to Mr. A. H. Howell.

LOCALITIES VISITED AND TRAPPING RESULTS

Some account of the environmental conditions at these various points is called for.

(1) *Santa Rosa Island* (figs. 2, 10–13) is a sand reef, nearly 50 miles in length, and varying from less than a fourth-mile to a half-mile in width. It is separated from the mainland by a narrow strait, Santa Rosa Sound, having a width of from one-fourth mile to two miles, and a depth sufficient to float only vessels of the lightest draft.[11] The island is composed, for the most part, of intensely white quartz sand. A sample collected along the beach on the south side is but little darker than ordinary granulated sugar. That of the dune region, further inland, is somewhat more discolored, while along a narrow strip bordering Santa Rosa Sound, it is considerably darkened by mud of organic origin. The vegetation, in general, is sparse. Along the northern side, throughout perhaps the eastern third of the island, is a light stand of pines of two species, while small trees and

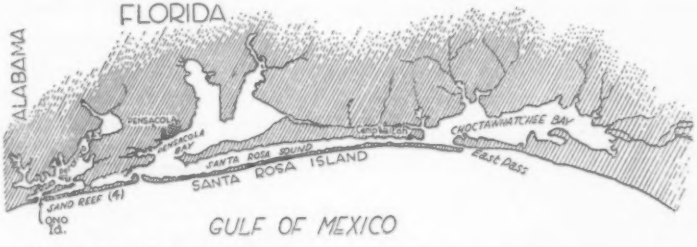

FIG. 2. MAP SHOWING LOCALITIES IN WHICH P. P. ALBIFRONS AND P. P. LEUCOCEPHALUS WERE TRAPPED BY THE WRITER IN 1924

shrubs of numerous species occur. Even here, however, the trees and shrubs are scattered, leaving wide tracts of exposed sand (fig. 11). The southern side of the island, on which most of the mice were trapped, consists of nearly barren sand, either level or thrown into dunes five to ten or more feet in height (figs. 12, 13). The prevailing plant here is the "sea oats" (*Uniola paniculata*), upon the seeds of which it is probable that the mice largely subsist. Scattered stunted shrubs of various species are, however, of frequent occurrence (starred in the following list). The appearance throughout the entire island, as seen from an elevation, is not unlike that of a snow-covered winter landscape in the north. The reflected light is extremely trying to the eyes, and to the skin of the face.

Following is a list of plants, collected by me on Santa Rosa Island, and kindly identified by Dr. J. K. Small, of the New York Botanical Gardens. It is not even approximately complete, since for the most part I collected samples

[11] In places, the water, even in the channel, is only six feet deep at mean low tide.

of only the commoner and more conspicuous species. **Pinus Elliotti* Engelm., *Pinus clausa* Chapm., *Taxodium distichum* (L.) L. C. Rich, *Andropogon* sp., *Panicum* sp., **Uniola paniculata* Linn., *Serenoa repens* (Bartr.) Small, **Smilax Beyrichii* Kunth., *Cerothamnus pumilus* (Michx.) Small, **Quercus geminata* Small, *Quercus myrtifolia* Willd., *Quercus Virginiana* Mill., **Magnolia foetida* (L.) Sarg., *Rubus* sp., *Bradleia frutescens* (L.) Britton, **Galactia parvifolia* A. Rich., **Ceratiola ericoides* Michx., *Cyrilla racemiflora* L., **Ilex glabra* (L.) A. Gray, **Ilex vomitoria* Ait., *Muscadinia Munsonia* (Simpson) Small, *Hypericum aspalathoides* Willd., *Opuntia ammophila* Small, *Kalmiella hirsuta* (Walt.) Small, *Desmothamnus nitidus* (Bartr.) Small, *Xolisma ferruginea* (Walt.) Heller, *Vaccinium Myrsinites* Lam., *Physalis angustifolia* Nutt., *Conradina canescens* (T. & G.) A. Gray, **Chrysoma pauciflosculosa* (Michx.) Greene, and *Baccharis halimifolia* L.

P. p. leucocephalus, like *Peromyscus* in general, appears to be strictly nocturnal in its habits, and indeed unable to endure much exposure to the sun. The footprints of these mice are found in some abundance on the open sand, even at considerable distances from shrubs or other hiding places. Their holes are not uncommon, though far less so than those of the crab *Ocypode albicans Bosc*, a white species, which abounds upon this island, as well as upon the neighboring mainland.[12]

Various predacious mammals inhabit the island, the chief of these being the domestic cat, which is said to have been introduced in large numbers, and whose footprints are frequently seen. Tracks of the raccoon and skunk are also not uncommon, and I am informed that the opossum (which likewise probably devours mice) occurs here.[13] As further probable enemies of *leucocephalus* we must add snakes, of which several species occur on the island. So far as the need of these mice for concealment is concerned, however, it is likely that the most important predators are owls. None of these were seen by me, but it is fair to assume that they are present, and that their rodent-catching propensities are the same here as elsewhere.

Eighty-nine specimens of *leucocephalus* were taken with "Delusion" mouse-traps, as the yield of 540 trap-nights. Of these, all were living except three. They comprised thirty-seven males, fifty females and two of unknown sex (partly eaten). No very young individuals were taken, nor any pregnant females. This is a rather curious circumstance, since in captivity some young have been obtained from this subspecies at all times of the year.

The only other rodent trapped by me on Santa Rosa Island was the cotton rat, *Sigmodon hispidus*, of which eight specimens were taken.

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[12] For the identification of this crab and some further information I am indebted to Dr. Mary J. Rathbun. Longley (Proc. Nat. Acad. Sci., Oct., 1917) has shown for this and several other crabs that "the shade of the substratum plays a very important part in determining that of the individuals resting upon it." It is conceivable, though hardly probable, that the coat color of mammals may likewise be influenced by optic stimuli, perhaps only after many generations.

[13] For this and other information, I am indebted to Mr. Philip Appleby, a young amateur naturalist who spends his summers at Camp Walton and has done considerable trapping in this region.

(2) *Mainland bordering Choctawhatchee Bay.* A hundred traps, set here for one night, within a mile or two of Camp Walton, yielded three specimens of *Peromyscus gossypinus*, but not a single member of the *polionotus* group. The shores in this region are mainly wooded close up to the beach, and no *Uniola* was seen. A similar result followed a night's trapping (109 traps) in a wooded and brush-covered region on the peninsula south of Choctawhatchee Bay. In this case, not a single mouse of any sort was taken. These rather meagre observations are worth recording as evidence, so far as it goes, that *P. p. albifrons* is primarily a race which occupies open sandy areas, and that it tends to avoid woods or dense brush.

(3) *Mainland, fronting on the Gulf of Mexico, east of the eastern end of Santa Rosa Island.* Here, in every way save one, we meet with the same environmental conditions as those found on Santa Rosa Island. Bordering the sea is a strip about a quarter of a mile wide, made up of dunes and beaches of the same intensely white sand, clad with the same sparse vegetation (*Uniola* and several shrubs,—see above). Ecologically, of course, the essential difference lies in the fact that the white sandy area of the mainland is directly continuous with far more extensive tracts in which the color of the background is quite different.[14]

Despite the identity of conditions in the immediate environment of these animals, a quite different race (*P. p. albifrons* Osgood) is found upon the shores of the mainland. Forty-two specimens of this latter race (twenty-five males, seventeen females) were the outcome of four nights' trapping (385 trap-nights) throughout a region extending about four miles east of Santa Rosa Island. Some of these were caught within a few hundred feet of the narrow strait (East Pass) which here separates the island from the mainland. Indeed, specimens of *leucocephalus* and *albifrons* were trapped within a half-mile of one another. No traces of intergradation were found, however, either on the island or the mainland. Specimens of *albifrons* from the East Pass region average somewhat paler, it is true, than ones from the territory next to be considered, but the dorsal colored area is more extensive, and in some other respects, they differ more widely from *leucocephalus* than do these last.

(4) *Reef west of Pensacola.* This is a peninsula, having the form of an inverted T, with a very short stem, connecting with the mainland, and long lateral branches running parallel with the coast (fig. 2). The eastern branch is separated from the mainland by Big Lagoon, the western branch extending across the mouth of Perdido Bay. The resort, Gulf Beach, is situated near the junction of these two. Despite the considerable length of this reef (about 13 miles), no name is given

[14] I have made some inquiries as to the extent of pure white sand along the coast of Alabama and Florida. Dr. Eugene A. Smith, State Geologist of Alabama, informs me that it extends westward at least as far as Fort Morgan, at the mouth of Mobile Bay. Eastward, I am informed by Mr. G. M. West of St. Andrews, Florida, it extends to Cape St. Blas, disappearing in the neighborhood of Apalachicola Bay, but recurring in places considerably farther along. This type of sand is, however, chiefly characteristic of beaches on the exposed coast. Those bordering the inclosed bays are probably of the more familiar hue of beaches elsewhere.

to it, either on the Coast and Geodetic or the Geological Survey map of this region.[15]

Both branches of this reef are composed of the same sort of intensely white sand as Santa Rosa Island. In general, vegetation is even less dense. Sea oats occurs in abundance in some places, and widely scattered pines extend throughout a large part of the length of the western branch. The base of the peninsula (stem of the T) is clad with rather dense pine woods and shrubbery, extending to some distance inland. While no trapping was done at this latter point, the conditions are such as to appear unfavorable for the occurrence of *P. p. albifrons*. So far as this mouse is concerned, therefore, we may suppose that the reef is isolated to a high degree, though not absolutely.

Forty-seven specimens of *albifrons* were taken as the yield of 307 trap-nights, chiefly on the western branch of the reef. Of these specimens, twenty-eight were males, nineteen being females. Three were in juvenile pelage. Since it was impossible for me to reach most of these traps until some hours after sunrise,[16] a considerable proportion of the animals (38 per cent) succumbed from heat, either before I could reach them, or before they could be transferred to cooler quarters.

One *Sigmodon hispidus* and two *P. gossypinus* were likewise trapped on this peninsula.

An interesting statistical fact, which appears from the foregoing trapping records relates to the abundance of *albifrons* in this region. The yield averaged about fifteen per one hundred trap-nights, a figure approaching very closely that (sixteen) found in trapping *leucocephalus* on Santa Rosa Island. Despite their practical identity of habitat, the darker race would thus seem to maintain itself as well as the paler and better adjusted race. And in this connection, the almost complete isolation of our peninsula must be borne in mind. This argument does not, of course, refute the "protective coloration" interpretation, as applied to *leucocephalus*, for other factors doubtless enter into the situation. But it does make it difficult to believe that a very intense selective elimination on the basis of color is taking place.

(5) *Ono Island*. The shape and position of this island are shown in figure 2. On its southern face, it is made up of sand nearly or quite as white as that of the outer reef. The main body of the island is, however, clad with pines and scattered shrubs, while the whiteness of the sand is considerably reduced. The northern shores, so far as seen, are swampy and muddy.

Forty-two *albifrons* (19♂, 21♀, 2?) were trapped along the northern shore of this island (140 trap-nights). Of these, sixteen were either dead when found, or died subsequently, for reasons mentioned above. As will be pointed out later, the limited surviving collection from Ono Island exhibits quite noticeable mean differences, in color characters, as compared with the mice of the adjacent reef. The channel separating the two is, in places, only a few hundred feet wide.

(6) *St. George Island*. This is a long reef, skirting the Florida coast, near Apalachicola, about 150 miles southeast from Pensacola. It is similar in many

[15] The War Department designates as Foster's Bank the site of Fort McRee, at the eastern end of this reef.

[16] I was obliged to live in Pensacola, and to make the trip, first by automobile and then by rowboat. The weather at this time was distressingly warm.

respects to Santa Rosa Island, but differs from the latter in the quality of its sand, and likewise in being separated from the mainland by several miles of water. It was visited in the hope that another distinct island type, perhaps modified in the same direction as *leucocephalus*, might be found there. I had been misinformed as to the color of the sand, however, which (so far as seen) proved to be chiefly of a buff hue, very different from that of Santa Rosa Island and the open coasts in the vicinity of Pensacola.

My results here were entirely negative, despite conditions which seemed to be highly favorable for the occurrence of mice of this group. One hundred traps each were set on two nights, in two widely separated parts of the island, largely upon sand dunes, bearing an abundant growth of *Uniola*. The only animals taken were fifteen specimens of *Peromyscus gossypinus*. Such a limited test does not, of course, entirely disprove the occurrence of any representative of the *polionotus* group on St. George Island, but I think it is fair to say that, if present at all, it is very scarce.

(7) *Farm near Autaugaville, in central Alabama.* Eight days were spent on the farm of Henry Golsan, about four miles from Autaugaville. My hearty thanks are due to Mr. and Mrs. Golsan, of whom I was a guest during this period, and to members of their family, who contributed much to the success of my visit.

The Golsan farm comprises an extensive tract, lying in the "Central Prairie Region" of the state.[17] Only part of this farm is under cultivation, the remainder being occupied by woods, swamps and open fields. The trees of this locality include, for the most part, hardwood species, though pines and red cedar occur.

The soil of the plowed fields is light and sandy, and when dry is of a distinctly brownish hue, lying, approximately, between the "Sayal Brown" and "Snuff Brown" of Ridgway's Color Standards. When damp, it is of course much darker. Practically all of the *polionotus* were taken within or on the borders of fields devoted to corn, cotton and peanuts. Within these fields, in particular, their holes were fairly abundant, the open burrows often being accompanied by small mounds of excavated soil. The mice are known to do considerable damage by digging up the planted seeds.

Mr. Golsan, who has considerable knowledge of local wild life, informs me that *polionotus* is not to be found in the woods. And yet, before cultivation, most of this region was wooded. It is not unlikely, therefore, that these mice have extended their range as more and more land has been devoted to agriculture.

Fifty-five specimens of *P. polionotus polionotus* (31 ♂, 22 ♀, 2?) were captured on the Golsan farm as the yield of 526 trap-nights. Of these, all but one were living. Contrary to my experience with the two other subspecies, the majority of the specimens of *polionotus* were immature, some being not over half-grown. The complete trapping record includes one *Peromyscus gossypinus* and eight *Mus musculus*.

Of the mice which were trapped in the foregoing localities, seventy-nine specimens of *leucocephalus*, ninety-three *albifrons*, fifty-three *polionotus*, and five *P. gossypinus* were sent to La Jolla. Of these, all were received in good condition except fourteen specimens of *albifrons*, contained in the last shipment, which died en route.

[17] See Mohr: Plant Life of Alabama. Geological Survey of Alabama, 1901.

CHARACTERS MEASURED

In various previous papers, I have given brief but quite inadequate accounts of the characters studied, and of the methods employed in measuring these. This summary treatment has been largely due to the fact that I have long planned to prepare a paper detailing the special technique which I employ in the capture, rearing and study of *Peromyscus*. Such a detailed account is highly desirable, both in order to make clear to the reader the exact nature of the characters with which I have been dealing, and in order that future investigators may be in a position to obtain comparable results. Since it is now my definite intention to devote the next paper that I publish exclusively to these matters of technique, I shall once more ask the reader to be content with an inadequate presentation of the subject.

The following sixteen "characters" are the ones considered in the present studies (table 1).

(1) *Body length* comprises the length of the head and trunk combined. It is the "total length" of most mammalogists, minus the length of the tail.

(2) *Tail length* (*absolute*), in my practice, is probably nearly equivalent to the value commonly given for "tail vertebrae." It represents the distance from the first (free) tail vertebra to the tip of the tail, the terminal hairs being left out of consideration.

(3) *Relative tail length* (*"Tail per cent"*) is obtained by dividing absolute tail length by the body length.

(4) *Foot length* is the distance from the heel to the tip of the claw of the middle digit, the foot being fastened to a flat surface by a pin. The left foot is used for measurement.

(5) *Ear length* is the distance from the bottom of the "notch" to the tip of the pinna of the left ear.

The foregoing measurements are determined with calipers and recorded in millimeters (tenths for the last two). Wherever possible, freshly killed animals are used for the purpose, though it is occasionally necessary to measure ones which have died of disease or injury.

(6) *Weight* is recorded in grams and tenths.

(7) *Width of tail stripe* is a relative value, being the ratio of the width of the dorsal tail stripe (midway in its length) to the entire circumference of the tail. In taking these measurements, the skin of the tail is split lengthwise, and spread out flat.

(8) *Length of tail stripe* is a character not previously employed by me, since this stripe, in most species, extends throughout the entire exposed part of the tail. In *albifrons*, however, and in some of my hybrid stock, the stripe is rudimentary, extending but a fraction of the distance from base to tip. The absolute length of this imperfect stripe is the value here considered.

(9) *Foot pigmentation* indicates the depth of color of the sole of the foot, graded

according to an arbitrary scale of five values. Owing to their generally low grade of foot pigmentation, somewhat different standards have been adopted for the mice of the *polionotus* series, as compared with previous ones. Thus, the mean values here given would be somewhat too high, according to my earlier standards.

In the present group of mice, it has been particularly important to obtain fairly precise quantitative expressions both for the extent and for the color value of the pigmented area of the hair. In the case of most species of *Peromyscus*, the ventral surface of the body, and frequently the lateral regions, extending up to a certain level, are covered with hair of whitish appearance. Upon close inspection, the hairs of these parts of the body are seen to be heavily pigmented throughout the basal half or more of their length, the distal half (or less) being pure white. It is the varying proportions of these two bands which give the varying degrees of

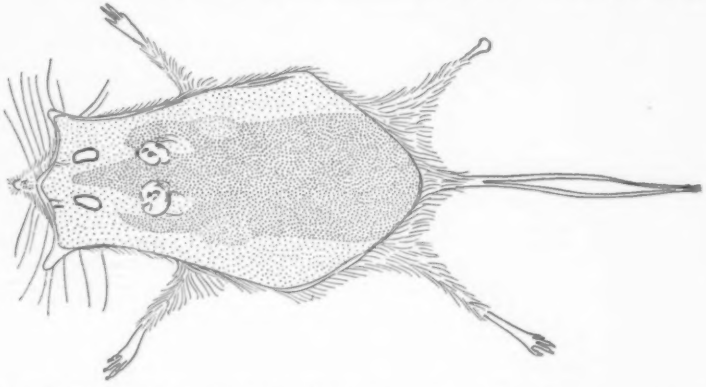

FIG. 3. SKIN OF P. P. ALBIFRONS, VIEWED FROM UNDER SIDE, ILLUSTRATING THE WRITER'S METHOD OF PREPARING SKINS FOR QUANTITATIVE STUDIES OF THE PELAGE

Absence of left foot is due to removal of this member for examination of pigment. The closely stippled area represents the "area of hair pigmented at base," considered in the present paper.

whiteness or grayness to the ventral surface, in different races of the mice. *P. p. polionotus* agrees with the more typical members of the genus in retaining this simple condition.

In our other two subspecies, however, the situation is more complex. We have three areas or zones of the pelage to be distinguished: (a) a zone in which the hair is pigmented from base to tip,[18] (b) one in which it is pigmented at the base, but not in its more distal portions; (c) one in which the entire hair, from base to tip is

[18] Strictly speaking, both the extreme base and the extreme tip are actually lacking in pigment, even in this region.

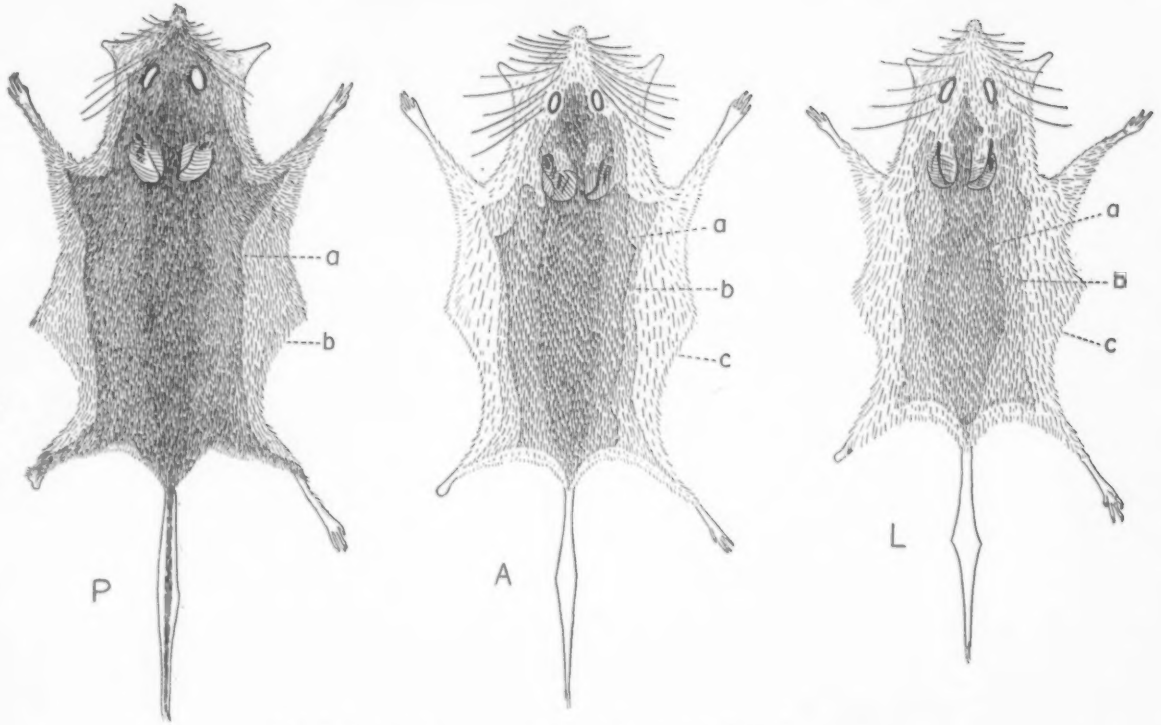

FIG. 4. PELAGE AREAS OF THE THREE SUBSPECIES HERE CONSIDERED

L = *leucocephalus;* A = *albifrons;* P = *polionotus;* a, b and c are the areas thus designated in the text. The reader should not be confused by the dark mid-dorsal stripe in P and A. This forms part of area a.

devoid of pigment, that is, is pure white. These areas are represented in figures 4 and 5.

(10) *Area of hair pigmented at base.* This manifestly includes both "a" and "b', in the preceding paragraph. Its value may be determined with tolerable accuracy in *leucocephalus* and *albifrons*, by the use of a polar planimeter. The

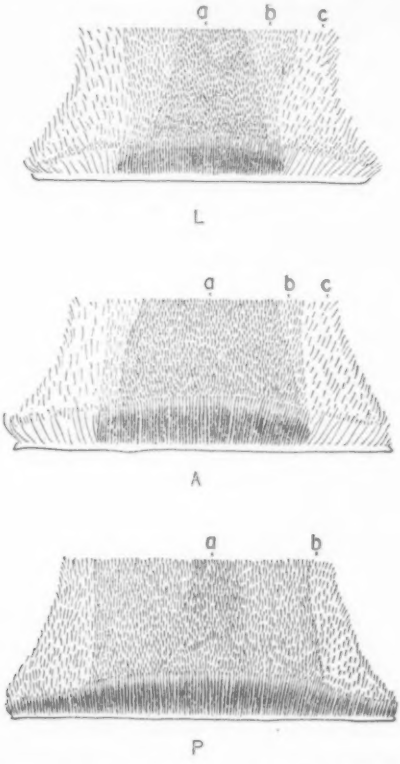

FIG. 5. APPEARANCE OF THESE PELAGE AREAS AS SEEN IN SECTION

L = *leucocephalus;* A = *albifrons;* P = *polionotus;* a, b and c are the areas thus designated in the text.

skin is laid hair side down upon a ground glass plate, and illuminated from below by means of an electric light. Before using the planimeter, the skin is covered with a sheet of transparent celluloid. The total area of the skin as outlined in

fig. 3 is first traced, then the pigmented area.[19] The values employed in the present paper are percentages, representing the proportion of the surface occupied by hair which is pigmented at the base (including that pigmented throughout its length).

(11) *Area of hair pigmented to tips.* This is the colored area of the pelage, as ordinarily considered. It can be determined with considerable precision in the case of *polionotus*, and with tolerable accuracy in the case of *albifrons*. With *leucocephalus*, on the other hand, it is impossible to measure the extent of this area, owing to the extremely ill-defined boundary between regions "a" and "b."

Thus for *leucocephalus*, figures are given only for the area of hair pigmented at base, for *polionotus* this is possible only for the area of hair pigmented to tips, while in the case of *albifrons* both sets of figures are available.

The five color values employed in these studies are obtained by the use of the Ives Tint Photometer, an instrument which has been discussed briefly by me in several previous papers.[20] Some understanding of this instrument, and of the methods which I have employed in using it, is quite essential for a proper evaluation of the data here presented. An adequate statement must be deferred, however, till the publication of the paper on technique in general, to which I have already referred.

I shall only repeat here that, in using this instrument, the object (in this case a definite area of pelage, centering at the middle of the dorsal surface) is viewed successively through three color-screens, along with a standard white block of magnesium carbonate, which it subjected to identical conditions of illumination. The light reflected from this standard white is controlled by an adjustable diaphragm, operated by a lever, which moves across a scale, graduated from 0 to 100. After each color screen is put into place, the lever is moved until the two halves of the field (the light from the object and that from the magnesia block) appear as of equal luminosity. Thus, a reading of 25, with the red screen, for example, indicates that the object reflects 25 per cent as much red light (of a given wavelength) as the standard block.

(12) *Red* (13) *Green*, and (14) *Violet*, as given in table 1, are means, based upon readings of this sort for the skins of each subspecies.[21]

For all rodent skins which I have studied, the reading for "red" is the highest, that for "violet" the lowest. In the case of *P. p. albifrons*, for example, the mean figures are approximately: red, 16.1; green, 11.9; violet, 9.8 It is hardly necessary to say that in a brownish or buff skin, such as this, *violet* is present only in so far as it is a component of white light. The percentage of violet (in this case 9.8) may therefore be taken as equivalent to that of white. Deducting this figure

[19] There are certain unavoidable defects in this method, such as, for example, my failure to split open the skin of the limbs.

[20] Journal of Mammalogy, May, 1921; May, 1924; Journ. Exp. Zool., Oct., 1922; Oct., 1923.

[21] It must be pointed out that the figures here given are not wholly comparable with those published in my previous papers, owing to a change of technique. I now cover the area of pelage under examination with a thin cover-glass, instead of leaving it exposed as formerly. With this procedure, the readings are somewhat lower.

from the other two, we have 6.3 and 2.1 as the percentage of "free" red and green, respectively.

As regards color and shade, skins may differ in several respects.[22] First of all, some may be merely *lighter* or *darker* than others, that is, they may differ in *luminosity*, the *color* (referring here to *wave-length*) being the same. Or they may differ in the amount of *white light*, with which the "free" colors are diluted. In other words, one skin may be highly colored (reddish or brown), another approaching neutral gray. Finally, skins may differ in the *spectral position* (*wave-length*) of their dominant color. In many cases, of course, the hair of two individuals differs in all three respects.

The value for "red", being the highest of the three readings here used, furnishes a good index of the luminosity (lightness or darkness) of a given individual or race. Thus, the darkest of our three subspecies, *polionotus*, gives a mean value of 9.5, the palest, *leucocephalus*, a mean value of 25.4, while the intermediate form, *albifrons*, gives a mean value of 16.1.[23]

(15) The fraction $\frac{R-V}{V}$ which is expressed in percentages, is an index of the amount of white light with which the "free" color is diluted. Thus a high value for this fraction indicates a highly colored skin, a low value one which is more nearly gray.

(16) *The ratio. R: G* is the ratio of "free" red to "free" green, that is, after deducting the amount of each regarded as belonging to the white light present (see above). Thus, in the case of *albifrons*, it is (approximately) $6.3 \div 2.1 = 3.0$.[24] This ratio furnishes an index of the spectral position of the dominant color This, in all cases, lies between orange and a yellow, a high value for this ratio indicating an approach to the former, a low value to the latter.

COMPARISON OF THE THREE SUBSPECIES IN RESPECT TO THE FOREGOING CHARACTERS

The most obvious of the differences between the three races here considered relate to the pigmentation of the hair. Figures 14, 15 and 16 indicate the differences of shade, but not, of course, the color values. The relative conspicuousness of these races against two types of natural background seems sufficiently striking and instructive.

If I followed the prevailing practice of designating the color values of these races according to Ridgway's color standards, I should describe the average condition of my *polionotus* skins as "clove brown on mid-

[22] For discussions of the underlying differences in the microscopic character of the hairs see Sumner, Amer. Nat., Apr.–May, 1918; Collins, Journ. Exp. Zool., Aug., 1923; Huestis, ibid., Apr., 1925.

[23] In some of my previous papers dealing with color, I have taken the complement of the percentage of red (i.e., 100—% red) as representing the percentage of "black." I have not dealt with "black" in the present paper.

[24] The figures in table 1 are based on the means of individual ratios.

TABLE 1

Mean values and variability of the various characters

CHARACTERS	SEX	NUMBERS			MEANS (CRUDE)			MEANS (CORRECTED)*			STANDARD DEVIATIONS		
		Polion.	Albif.	Leuc.	Polion.	Albif.	Leuc.	Polion.	Albif.	Leuc.	Polion.	Albif.	Leuc.
Body length (head + trunk)	Both sexes	46	78	72	80.49 ± 0.36	80.43 ± 0.22	80.23 ± 0.29				3.58	2.91	3.63
	♂	27	45	33	78.59 ± 0.23	78.71 ± 0.17	77.79 ± 0.24				1.77	1.71	2.08
	♀	19	33	39	83.18 ± 0.58	82.77 ± 0.30	82.29 ± 0.36				3.77	2.57	3.37
Tail length (absolute)	Both sexes	44	77	71	51.33 ± 0.32	53.59 ± 0.23	54.21 ± 0.20	50.96	53.34	54.10	3.19	2.93	2.49
	♂	26	44	33	49.98 ± 0.32	52.48 ± 0.27	53.27 ± 0.24	51.39	53.10	54.22	2.42	2.64	2.08
	♀	18	33	38	53.28 ± 0.50	55.08 ± 0.31	55.03 ± 0.28	51.16	53.67	53.77	3.16	2.63	2.53
Tail per cent (percentage of body length)	Both sexes	44	77	71	63.55 ± 0.23	66.60 ± 0.23	67.65 ± 0.20				2.26	2.99	2.51
Foot length	♂	27	45	33	17.306 ± 0.062	17.942 ± 0.048	18.517 ± 0.042	17.569	17.999	18.699	0.477	0.477	0.357
	♀	19	33	39	17.250 ± 0.084	17.986 ± 0.052	18.500 ± 0.051	16.895	17.785	18.360	0.544	0.446	0.472
Ear length	Both sexes	46	76	70	15.008 ± 0.068	14.620 ± 0.039	14.499 ± 0.038	14.965	14.588	14.483	0.682	0.500	0.476
	♂	27	44	31	14.926 ± 0.088	14.561 ± 0.051	14.273 ± 0.049	15.167	14.773	14.446	0.679	0.504	0.407
	♀	19	32	39	15.124 ± 0.104	14.702 ± 0.058	14.679 ± 0.048	14.804	14.504	14.572	0.670	0.484	0.449
Weight	Both sexes	41	74	63	12.77 ± 0.19	12.66 ± 0.10	12.87 ± 0.13				1.80	1.28	1.53
Tail stripe, width	Both sexes	38		72	29.26 ± 0.54		0				4.90		
Tail stripe, length	Both sexes		78	72		13.41 ± 0.98	0		13.08			12.86	
Foot pigmentation	Both sexes	45	75	68	1.47 ± 0.08	0.09†	0				0.83		
Area of hair pigmented at base	Both sexes		74	65		65.15 ± 0.49	45.54 ± 0.32		64.98	45.48		6.25	3.81
	♂		42	29		63.48 ± 0.64	45.21 ± 0.45		63.23	45.76		6.13	3.59
	♀		32	36		67.34 ± 0.68	45.81 ± 0.44		67.16	45.02		5.70	3.94
Area of hair pigmented to tips	Both sexes	46	74		73.96 ± 0.39	57.74 ± 0.59					3.91	7.52	
	♂	27			74.67 ± 0.49						3.75		
	♀	19			72.95 ± 0.60						3.91		
Red	Both sexes	45‡	75	64	9.55 ± 0.11	16.08 ± 0.14	25.40 ± 0.30	9.52	16.07	25.41	1.06	1.81	3.53
	♂	27	43	28	9.62 ± 0.14	16.19 ± 0.19	26.05 ± 0.45	9.74	16.25	26.37	1.07	1.86	3.50
	♀	18‡	32	36	9.44 ± 0.16	15.93 ± 0.20	24.90 ± 0.39	9.00	15.45	24.78	1.02	1.70	3.46
Green	Both sexes	45‡	75	64	7.28	11.94	20.78						
Violet	Both sexes	45‡	75	64	6.17 ± 0.07	9.78 ± 0.06	18.45 ± 0.28				0.69	0.78	3.30
$\frac{R-V}{V}$	Both sexes	45‡	75	64	54.98 ± 0.92	64.76 ± 1.36	38.61 ± 0.78				9.10	17.50	9.26
$R:G$	Both sexes	45‡	75	64	3.12 ± 0.048	2.97 ± 0.027	3.02 ± 0.031				0.48	0.35	0.37

* Reduced to a standard body length of 80 mm.

† Only 7 of the 68 *albifrons* feet which were examined showed any trace of pigment. These were graded as "1".

‡ One very aberrant individual (4991) has been omitted from the color computations. If included, the mean value of red would be 9.67, $\frac{R-V}{V}$ being 56.13.

dorsal surface, passing into olive brown laterally." The *albifrons* skins might be described as "olive brown dorsally, passing into buffy brown laterally," while the most highly colored parts in the mid-dorsal region of the *leucocephalus* skins approach "wood brown" or "light drab" in appearance. Such designations would give only roughly approximate impressions, however, for reasons which will be more fully discussed in a later paper.

Various other color differences have been noted, which have not been treated quantitatively, and which therefore do not appear in the tables. The ears, for example, show, in general, the same gradations of shade as the pelage, though the difference between *albifrons* and *leucocephalus* is far less pronounced than that between either of these and *polionotus*. These differences are due, in part, to differences in the pigmentation of the skin itself, aside from the presence of differently colored hairs.

A rather surprising pigmental difference was detected in examining the bodies of the mice after skinning. It was found that the (skinned) tails of *polionotus* commonly appeared darker than those of the other races, owing to pigment in some tissue, perhaps the periosteum surrounding the vertebrae. *Leucocephalus* was not observed to display any such internal pigmentation, while in *albifrons* the condition seemed to be intermediate, the animals exhibiting less pigmentation than *polionotus*, or lacking it altogether.[25]

Let us pass to the sixteen "characters" which have been discussed in the preceding section of the paper (see table 1). It should be said that the animals here dealt with are exclusively "wild" specimens, trapped in the field. With a few exceptions, these animals were kept for many months in captivity before they were killed and measured. It may be presumed, therefore, that we are dealing almost exclusively with fully mature mice. The few possible exceptions are ones which died in captivity, and which were nearly if not quite mature at the time of death.

(1) *Body length.* The mean size of the three series of specimens, both as regards body length and weight, agrees surprisingly, considering the rather wide variability, in this respect, of each of the subspecies. The small size of the species here dealt with, in comparison with mice of the *Peromyscus maniculatus* series, is evident by comparing the mean body length of the former (about 80 millimeters) with that of *P. m.*

[25] These observations were not extended through my entire series, but were made frequently enough to render probable the racial differences here noted.

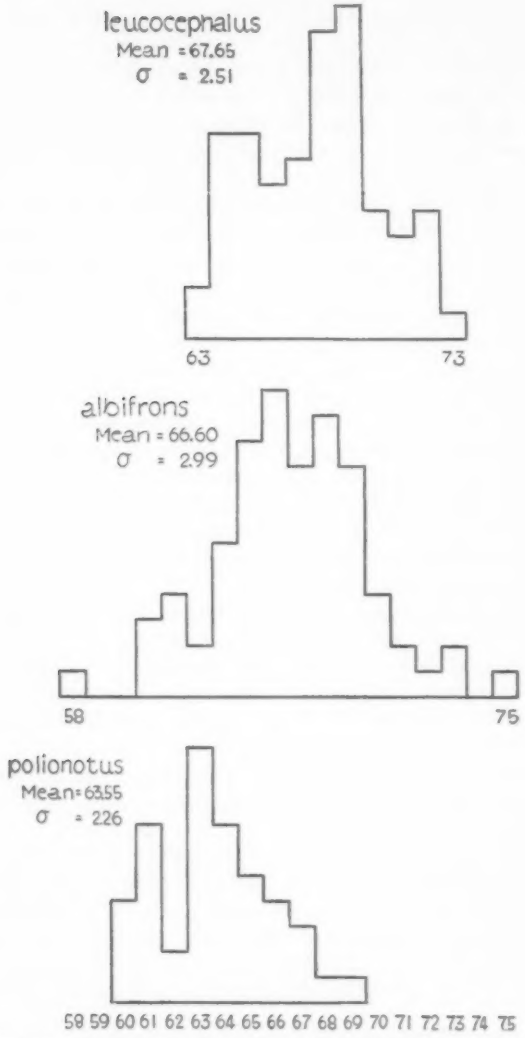

FIG. 6. HISTOGRAMS SHOWING FREQUENCY DISTRIBUTIONS OF RELATIVE TAIL LENGTH ("TAIL PER CENT"), IN THE THREE RACES

gambelii (over 90 mm.), *sonoriensis* (89 mm.), *rubidus* (90 mm.), or *dubius* (102 mm.).[26]

An interesting sexual difference in size is quite pronounced in all three of our present subspecies. The females average more than 4 mm. longer than the males. Smaller differences in the same direction are shown by twelve out of thirteen of my (adequate) local collections of *maniculatus*, from California and Arizona. In these last, the average body length of the females exceeds that of the males by from 0.4 to 3.6 millimeters.

(2) *Tail length, absolute*, and (3) *tail length, relative*. (See histograms, fig. 6.) This species is distinctly a short-tailed member of the genus, both absolutely and relatively. It appears from the table that both *albifrons* and *leucocephalus* exceed *polionotus* slightly, though significantly in the length of this appendage. The much smaller difference between the two first of these races, in favor of *leucocephalus*, may be regarded as doubtful, in view of the magnitude of the probable errors.

Through the kindness of A. H. Howell, I have measurements ("total length," "tail vertebrae" and "hind foot") of fifteen specimens of *polionotus*, fifteen *albifrons* and seven *leucocephalus*, contained in the U. S. Biological Survey collection at the National Museum. Despite the limited number of specimens, and the fact that they were measured by several different collectors, it is interesting to note that the relations of the three subspecies are substantially as I have found them, that is *leucocephalus* and *albifrons* are nearly equal in respect to relative tail length, while both of these races have longer tails than *polionotus*.

That the sexual differences in mean tail length which are shown in table 1 are due entirely to the greater average size of the females is seen by comparing the "corrected" means.

(4) *Foot length*. As I have frequently pointed out in the past, the sexes of *Peromyscus* and some other rodents differ characteristically in the mean relative size of the foot, that of the female being smaller. In the present material, this tendency is revealed at once by the fact that the mean absolute foot length of the males slightly exceeds that of the females in two series out of three, despite the considerably greater average body size in the latter sex. When these means are corrected (the animals being reduced to a standard body length of 80 mm.), the excess in favor of the males is seen to average about 0.4 mm.

It is obvious, therefore, that we can compare only individuals of the

[26] In each of these latter series, a considerable number of immature mice were included, so that the racial difference is actually greater than is here indicated.

same sex in seeking for differences between our subspecies. Thus considered, our three races all differ significantly from one another in respect to foot-length, *leucocephalus* having the longest foot and *polionotus* the shortest.

In the males the difference between *leucocephalus* and *albifrons* is greater than that between *albifrons* and *polionotus* (using here the corrected means); in the females the situation is reversed. But the racial differences here indicated are in all cases statistically significant, and the difference between *leucocephalus* and *polionotus* (about 1½ mm.) is to be regarded as a large difference, in view of the small size and low variability of this member.[27]

The inferior foot-length of *polionotus*, as compared with the other two races, is shown even in the limited series of Biological Survey specimens, above referred to, although the measurements, in most cases, were only made to the nearest millimeter. The difference between *leucocephalus* and *albifrons*, does not, however, appear.

(5) As regards *ear length*, three facts are evident from the table. First, *leucocephalus* and *albifrons* are in substantial agreement. Second, both of these races, although they possess *longer* tails and feet than *polionotus*, possess *shorter* ears. Third, the sexes do not differ significantly in respect to this member.

(6) *Weight* has already been referred to in discussing body length. It is substantially equal in the three races. It should be explained that females known to be pregnant, or mice of either sex which were emaciated through sickness have been excluded from these computations.

(7) *Tail stripe width*. It has been possible to measure this only in the case of *polionotus*. The mean figure (29.26) is considerably lower than that previously found for the darker races of *P. maniculatus*, and only slightly exceeds that for the pale desert race *P. m. sonoriensis* (28.12).

(8) *Tail stripe length*. This is only recorded for *albifrons*, in which the mean length of the rudimentary stripe is 13.41 millimeters, or almost exactly one fourth of the total length of the tail. This figure becomes 18.23 millimeters, if we omit the twenty-one specimens from the peninsula west of Pensacola (locality no. 4). Of these last, only three individuals show any tail stripe whatever. In *polionotus*, the stripe extends throughout the entire length of the exposed part of the tail, in *leucocephalus* it is lacking altogether.

[27] The three local collections of *albifrons* (see below) appear to differ significantly in respect to foot length, as in some other characters. In respect to this character, the East Pass series is exceeded by both of the others.

(9) *Foot pigmentation* was plainly discernible only in *polionotus*, in which it occurred in the four grades 0, 1, 2, and 3, the mean figure being 1.47. In only seven specimens of *albifrons* were the feet sufficiently pigmented to be given a grade of 1, and even this rating was given doubtfully in some cases. A single specimen, out of the sixty-eight *leucocephalus* feet which were examined, was doubtfully given the rating 1. The rest were rated 0.

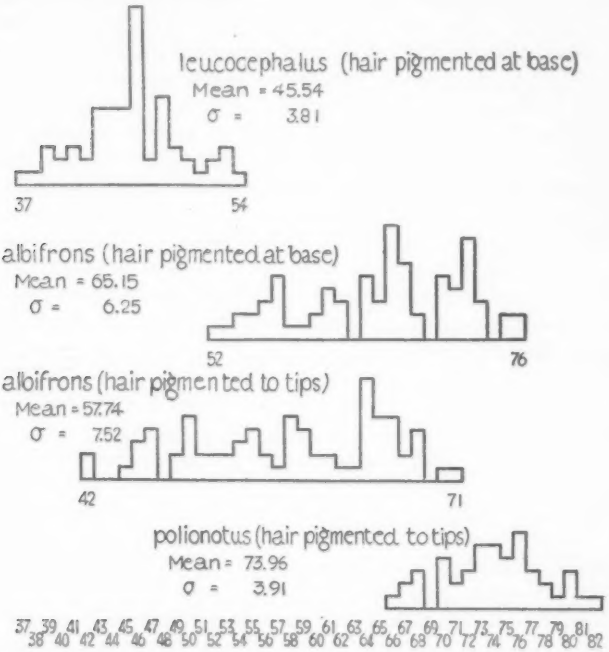
leucocephalus (hair pigmented at base)
Mean = 45.54
σ = 3.81
37
54
albifrons (hair pigmented at base)
Mean = 65.15
σ = 6.25
52
76
alboifrons (hair pigmented to tips)
Mean = 57.74
σ = 7.52
42
71
polionotus (hair pigmented to tips)
Mean = 73.96
σ = 3.91
37 39 41 43 45 47 49 51 53 55 57 59 61 63 65 67 69 71 73 75 77 79 81
38 40 42 44 46 48 50 52 54 56 58 60 62 64 66 68 70 72 74 76 78 80 82

FIG. 7. HISTOGRAMS SHOWING EXTENT OF PIGMENTED AREA OF HAIR, REGARDED AS PERCENTAGES OF ENTIRE AREA OF PELAGE

(10) *Area of hair pigmented at base.* (See histograms, fig. 7.) I shall repeat that this includes the zone in which the hair is pigmented throughout its entire length, as well as that in which hair pigmentation is restricted to the base. In the case of *polionotus*, such hair covers the entire trunk, so that this character is not recorded for that subspecies. It has, however, been determined for the other two races.

The salient point in our table is the fact that in *albifrons*, colored hair covers a much larger proportion of the body than in the paler race *leucocephalus*, the mean figures being 65.15 and 45.54, respectively. Attention must likewise be called to what seem to be significant local differences within the subspecies *albifrons* itself. The thirty-nine skins from the mainland east of Santa Rosa Island give a mean value of 66.46 for this character; twenty specimens from the reef west of Pensacola (no. 4) giving a mean value of 56.80; and fifteen specimens from Ono Island, a mean value of 72.87. It must be stated, moreover, that the lowest value for the third of these sets of specimens (71) is considerably higher than the highest value for the second (61). These figures emphasize the fact that the "*albifrons*" here considered is a composite mixture of local races, which differ quite appreciably from one another, although less widely than they differ from the other two subspecies with which we are dealing. Furthermore, Osgood's statement, in his diagnosis of *albifrons*,—"end of nose and narrow stripe extending nearly to interorbital region white or whitish"—holds for only a minority of my specimens from any of these localities.

The apparent sexual difference in the extent of the pigmented area, which is shown by our table, results from the unequal distribution of the sexes in these three groups.

(11) *Area of hair pigmented to tips.* (Fig. 7.) In the case of *polionotus*, table 1 gives this figure for the sexes combined, and for the males and females separately. There is here shown a probably non-significant sexual difference. *Polionotus*, as might have been expected, has a larger colored area than the paler race *albifrons*, the mean values being 73.96 and 57.74, respectively. Comparison of the two "pigmented area" figures for *albifrons* (65.15 and 57.74) gives an idea of the relative extensity of the area "a + b" as compared with "a" alone.

(12) The values for *red* (fig. 8) furnish, among other things, a good index of the relative darkness or paleness of the three races, *polionotus* giving us a mean reading of 9.55, *albifrons* 16.08, and *leucocephalus* 25.40.

Attention should be called to a single, highly aberrant specimen of *polionotus*, which gave a reading of 15.0, the next palest specimen giving 11.7. This aberrant individual has been omitted from the present computations.

We must note, likewise, the existence of rather pronounced local differences within the heterogeneous race designated as *albifrons*. Our limited local collections from the eastern and the western beaches of

the mainland (localities 3 and 4, above) and from Ono Island, give mean values of 17.17, 15.07, and 14.51, respectively. Since the variability for this character is low, the differences between the first and the two last of these figures, at least, is probably significant. Indeed, to mere casual inspection, the Ono Island series appears darker than that from the East Pass region, and this impression is strengthened by the greater extent of the pigmented area in the former.

Figures for the "corrected means" for this character agree in giving a slightly higher value to the males than to the females. None of these

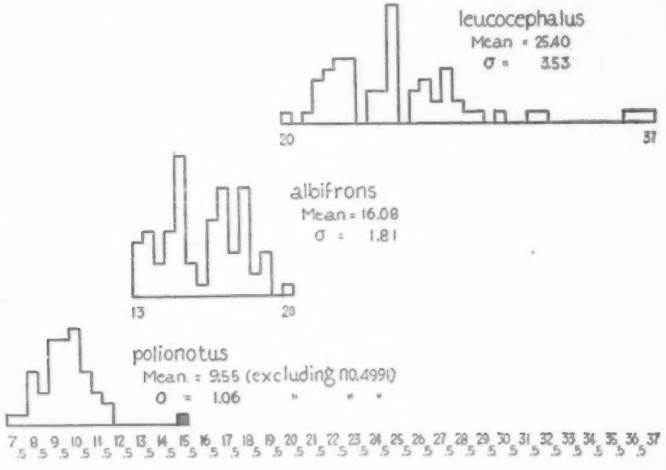

FIG. 8. HISTOGRAMS SHOWING VALUES OF "RED," AS DETERMINED BY THE TINT-PHOTOMETER

A highly aberrant specimen of *polionotus* is indicated by cross-shading

differences is statistically significant, however, while that for *albifrons* seems to be due entirely to the different proportions of the sexes in the three local groups.

(13) *Green* and (14) *violet* need not detain us. As already stated, the latter figure may be regarded as indicating the percentage of "white" in the mixture. This, of course, is highest in *leucocephalus* (18.45), lowest in *polionotus* (6.17), and intermediate in *albifrons* (9.78).

(15) The fraction $\frac{R-V}{V}$ (fig. 9), as already stated, is an index of the

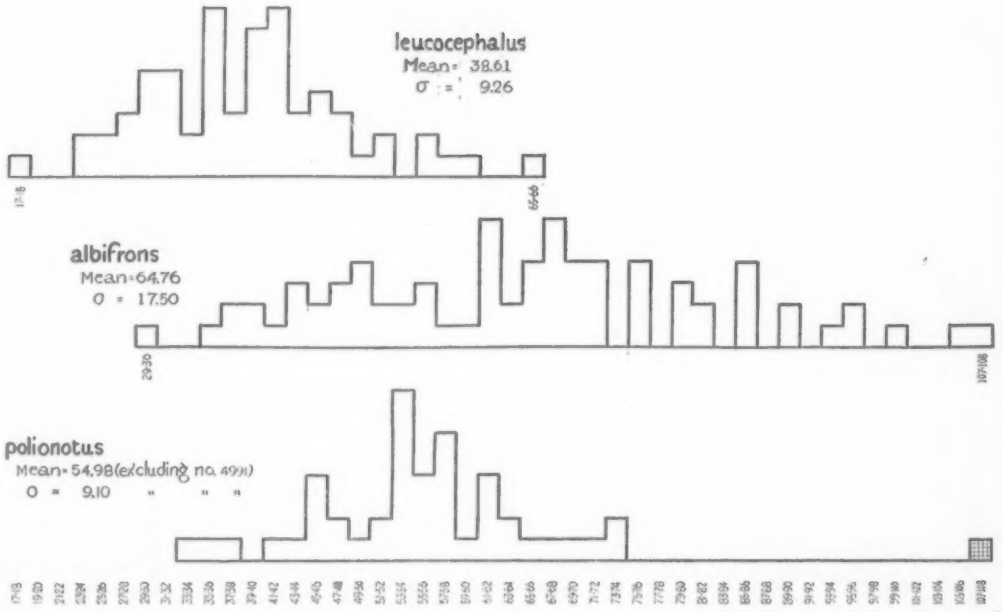

FIG. 9. HISTOGRAMS SHOWING VALUES OF THE FRACTION $\frac{R-V}{V}$.

High values of fraction indicate highly colored skins, low values implying ones more nearly gray. Aberrant specimen of *polionotus* indicated as in preceding figure.

relative purity of the color, or conversely, of its dilution with white. It is low (38.61) in *leucocephalus*, which, as previously stated, is not only extremely pale, but largely lacking in color, the pigmented area of the hair being more nearly gray than in the other two races.[28] *Albifrons*, in the aggregate, shows the highest mean value of all for this character (64.76), *polionotus* in this case being intermediate (54.98).[29] I must point out, once more, the differences in our three local collections of *albifrons* in respect to this character. The series from the eastern and the western beaches and Ono Island, respectively, give means of 74.00, 61.25 and 44.80. The first appear, at a glance, to average far less gray than the last.

(16) The *R:G ratio*. The mean value of this ratio (approximately 3) is close to that found in most previous races of *Peromyscus*. It is doubtful whether the three figures here given differ significantly. It is thus plain that the widely different appearances of the pelages of these various mice are due to varying proportions of "black," "white" and "color," not, to any considerable extent, to differences in the quality (wave-length) of this color itself.

The foregoing review of the data contained in table 1, together with an inspection of the histograms (figs. 6–9) and of the photographs (figs. 14–16) should convince the reader that we are dealing with quite distinct local types. They are distinct, not only in the sense that the mean values for many of the characters lie far apart, but in the sense that for certain characters, for example red, the ranges of variation for our three collections do not overlap at all.[30] One could sort out all of the specimens unerringly, should they be mixed together.

Objection may be made to treating the composite group "*albifrons*" as a single race. This I have believed to be a justifiable procedure for present purposes, owing to the fact that the local series of *albifrons* here considered differ, in general, far less from one another than they do from either of the other subspecies. Furthermore, even as thus constituted, the variability of *albifrons* is no higher than that of the other two subspecies, as an inspection of the standard deviations (table 1) will show.

[28] Some specimens, however, are quite distinctly buff or yellowish.

[29] Omitting the figure (108) for the aberrant, highly colored individual. (See p. 172 above).

[30] This is only true (fig. 8) if we omit the single aberrant specimen of *polionotus*. *Leucocephalus* and *albifrons* appear to overlap at one point (20), but even this would not be true if fractions had been considered.

differences in body size have been eliminated, individuals with longer tails tend to have longer feet. It is probable that the parallel modification of these members is due, in part at least, to the fact that they are influenced by the same genetic factors, or by closely linked factors.

On the other hand, parallel gradients are shown in the present three races of mice in respect to foot-length and paleness of the pelage. Both characters follow the order: *leucocephalus* > *albifrons* > *polionotus*. Are then foot length and color correlated within the single race? We must probably answer this question in the negative. These changes seem to have resulted from the modification of independent genetic factors. If the parallel geographic gradients are not purely accidental, they must be due to the action of some unknown factor of the environment.

The correlation coefficients determined for the present material are presented in tables 2 and 3. For the sake of those who are unfamiliar with the meaning of these coefficients, it may be said that positive figures denote parallel variation in the same direction, negative ones variation in opposite directions. Perfect correlation (hardly ever present) would be designated by 1.0, but any coefficient of 0.5 or more is to be regarded as indicating a high degree of correlation. A coefficient has a fairly probable significance if it is three times as great as its probable error, the probability rising rather rapidly with this ratio. On the other hand, where the probable error is as great as or greater than the coefficient itself, the latter may reasonably be regarded as "accidental."

In table 2 are shown the correlations between body length and other characters. These have been computed for two reasons: (1) to reveal possible correlations between size and other characters not obviously related to this; and (2) to render possible the "correction" of the mean values given in table 1, as well as the computation of "net" coefficients (table 3).[36]

Correlations between body length and the length of the three members here considered (tail, foot and ear) could have been predicted with full confidence.

With the possible exception of body length and tail stripe width in

[36] The method of "multiple" or "partial" correlation has been employed in the latter case. One might be disposed to question the propriety of making any such "corrections" in cases where the correlation between the characters concerned is doubtful. However, even in such cases, the observed correlation is more probable than any other value, including zero.

TABLE 2

Correlations between body length and other characters

	SEX	POLIONOTUS		ALBIFRONS		LEUCOCEPHALUS	
		Number	r	Number	r	Number	r
Tail length	Both sexes	44	$+0.846 \pm 0.029$	77	$+0.570 \pm 0.052$	71	$+0.695 \pm 0.041$
	♂	26	$+0.732 \pm 0.061$	44	$+0.310 \pm 0.092$	33	$+0.431 \pm 0.096$
	♀	18	$+0.794 \pm 0.059$	33	$+0.509 \pm 0.087$	38	$+0.734 \pm 0.050$
Foot length	♂	27	$+0.693 \pm 0.067$	45	$+0.158 \pm 0.098$	33	$+0.479 \pm 0.091$
	♀	19	$+0.773 \pm 0.062$	33	$+0.418 \pm 0.097$	39	$+0.435 \pm 0.088$
Ear length	Both sexes	46	$+0.458 \pm 0.079$	76	$+0.433 \pm 0.063$	70	$+0.525 \pm 0.058$
	♂	27	$+0.444 \pm 0.104$	44	$+0.560 \pm 0.070$	31	$+0.401 \pm 0.102$
	♀	19	$+0.567 \pm 0.105$	32	$+0.381 \pm 0.102$	39	$+0.351 \pm 0.095$
Tail stripe*	Both sexes	38	$+0.315 \pm 0.099$	78	$+0.174 \pm 0.074$		
Foot pigmentation	Both sexes	45	-0.213 ± 0.096				
Pigmented area† of pelage	Both sexes	46	-0.231 ± 0.094	74	$+0.186 \pm 0.076$	65	$+0.243 \pm 0.079$
	♂	27	-0.092 ± 0.129	42	-0.053 ± 0.103	29	$+0.145 \pm 0.122$
	♀	19	-0.164 ± 0.150	32	-0.030 ± 0.119	36	$+0.295 \pm 0.103$
Red	Both sexes	45‡	$+0.207 \pm 0.096$	75	$+0.055 \pm 0.078$	64	-0.038 ± 0.084
	♂	27	$+0.145 \pm 0.127$	43	$+0.049 \pm 0.102$	28	$+0.086 \pm 0.126$
	♀	18‡	$+0.512 \pm 0.117$	32	$+0.263 \pm 0.111$	36	$+0.052 \pm 0.112$
$\frac{R-V}{V}$	Both sexes	45‡	-0.202 ± 0.096	75	-0.036 ± 0.078	64	-0.064 ± 0.084

* Width of tail stripe (taken as percentage of circumference) used in case of *polionotus;* length (absolute) in case of rudimentary tail stripe of *albifrons.*

† "Pigmented area," in case of *polionotus,* is limited to hair pigmented throughout its whole length; in *albifrons* and *leucocephalus,* it includes the entire area pigmented at base.

‡ Omitting specimen 4991, which is of very aberrant color.

TABLE 3

Correlation between various characters

	SEX	POLIONOTUS			ALBIFRONS			LEUCOCEPHALUS		
		Number	r (gross)	r (net)	Number	r (gross)	r (net)	Number	r (gross)	r (net)
Tail length and foot length	♂	26	+0.765	+0.526 ± 0.096	44	+0.248	+0.212 ± 0.097	33	+0.455	+0.314 ± 0.106
	♀	18	+0.780	+0.432 ± 0.129	33	+0.629	+0.532 ± 0.084	38	+0.597	+0.455 ± 0.087
Tail length and ear length	Both sexes	44	+0.442	+0.115 ± 0.100	75	+0.202	−0.061 ± 0.078	69	+0.404	+0.064 ± 0.081
Tail length and tail stripe*	Both sexes	36	+0.128	−0.274 ± 0.104	77	+0.097	−0.003 ± 0.077			
Tail length and pigmented area†	Both sexes	44	−0.260	−0.124 ± 0.100	73	+0.248	+0.176 ± 0.077	64	+0.239	+0.100 ± 0.083
Tail length and red	Both sexes	43‡	+0.134	−0.079 ± 0.102	74	+0.139	+0.131 ± 0.077	63	−0.014	−0.056 ± 0.085
Foot length and ear length	♂	27	+0.450	+0.221 ± 0.123	44	+0.184	+0.116 ± 0.100	31	+0.131	−0.076 ± 0.120
	♀	19	+0.456	+0.034 ± 0.155	32	+0.121	−0.046 ± 0.119	39	+0.405	+0.300 ± 0.098
Foot length and pigmented area	♂	27	−0.167	−0.144 ± 0.127	42	−0.224	−0.218 ± 0.099	29	−0.023	−0.106 ± 0.124
	♀	19	−0.120	+0.011 ± 0.155	32	−0.101	−0.097 ± 0.118	36	+0.290	+0.188 ± 0.103
Foot length and red	♂	27	+0.240	+0.195 ± 0.124	43	−0.296	−0.307 ± 0.093	28	+0.175	+0.154 ± 0.124
	♀	18‡	+0.366	−0.055 ± 0.159	32	−0.093	−0.231 ± 0.113	36	−0.245	−0.297 ± 0.102
Tail stripe and foot pigmentation	Both sexes	37	−0.002	+0.070 ± 0.110						
Tail stripe and pigmented area	Both sexes	38	+0.386	+0.499 ± 0.082	74	+0.620	+0.606 ± 0.050			
Tail stripe and red	Both sexes	37‡	−0.227	−0.314 ± 0.100	75	+0.003	−0.007 ± 0.078			
Pigmented area and foot pigmentation	Both sexes	45	+0.168	+0.125 ± 0.099						
Pigmented area and red	Both sexes	45‡	−0.426	−0.398 ± 0.085	74	−0.049§	−0.060 ± 0.078	64	−0.310	−0.310 ± 0.076
Pigmented area and $\frac{R-V}{V}$	Both sexes	45‡	−0.195	−0.253 ± 0.094	74	−0.211	−0.208 ± 0.075	64	+0.403	+0.432 ± 0.068

* Tail stripe width used for *polionotus*, length for *albifrons*.

† "Pigmented area" in *polionotus* is limited to hair pigmented throughout its whole length; in *albifrons* and *leucocephalus* it includes the entire area pigmented at base.

‡ Omitting specimen no. 4991, owing to its very atypical color.

§ −0.022 when area pigmented to tips is used.

polionotus, all of the other correlations in table 2 are ones which may well be the result of "errors of random sampling," that is, they have no probable significance.[37]

Passing to table 3, it must be pointed out that, for the coefficients which have been thus corrected, it is the "net" figures which concern us. These indicate the degree of correlation between two characters which would presumably be manifested in a series of constant size. Tail and foot length, for example, are both correlated with body length, and would accordingly be correlated with one another in a series of mixed size. The table shows that for each race and each sex these two members are positively correlated, independently of the size of the body.[38]

Tail length and ear length are not, however, correlated appreciably in these races, nor are foot length and ear length.

Appreciable correlations between any of these linear measurements (tail stripe not being here included) and pigmental characters of any sort are not revealed by these figures.

On the other hand, highly interesting correlations are to be observed among certain of the pigmental characters. Thus, the extent of the pigmented area of the pelage is strongly correlated with width of tail stripe (*polionotus*) and length of (rudimentary) tail stripe (*albifrons*). From this we may reasonably conclude that the same (or closely linked) genetic factors which are responsible for an increase in the colored area of hair on the trunk and head, are likewise responsible for an increase in the number of pigmented hairs on the dorsal surface of the tail. Whether the factors here involved are actually identical, or merely linked, may perhaps be revealed in the course of breeding experiments.

In harmony with the facts just noted, we find that width of tail stripe and paleness of hue (as indicated by the value for "red") appear to be negatively correlated to a moderate degree in *polionotus*. Such correlation with tail stripe length is not, however, shown in our aggregate series of *albifrons*, a circumstance which seems to result in part from the inclusion of three races differing considerably in the mean values for these two characters.[39]

[37] It must, of course, be remembered that low correlations can not from the nature of the case manifest themselves with certainty in small populations, such as those here considered.

[38] See also, Proc. Nat. Acad. Sci., Nov., 1923.

[39] In the largest of our local collections (that from the East Pass region), taken by itself, there is a strong negative correlation between tail stripe length

Pigmented area and red are likewise negatively correlated in *polionotus* and *leucocephalus*. In other words, specimens in which the colored areas of the pelage are more extensive, also tend to be of a darker shade. This corresponds with the association which we frequently meet with in comparing geographic races with one another.[40] That these two characters show no correlation in the present series of *albifrons* appears to be due to the circumstance referred to in the preceding paragraph. In the two largest local collections, treated singly, the negative correlation is pronounced.

In *polionotus*, the only one of our races having appreciably pigmented feet, no significant correlation is to be detected between the degree of this pigmentation and that of the hair. This is likewise in agreement with facts which I have reported for other races of *Peromyscus*. While pigmentation in various parts of the pelage tends to be rather closely correlated, that of the soles of the feet seems to be largely independent of this, so far as individual variability is concerned. In comparing geographic races, as has previously been pointed out, the two are frequently found to have undergone parallel modification.

The coefficients of correlation between the extent of the pigmented area and the fraction $\frac{R-V}{V}$ (see p. 165) are contradictory and at present only partly intelligible.

SUMMARY

A careful statistical analysis has been undertaken of certain linear and colorimetric characters of three well marked races of mice (*Peromyscus*) from Florida and Alabama which are now being reared for genetic purposes.

These races comprise a very pale, largely white form, *leucocephalus*, which is restricted to an island of intensely white sand; an intermediate form, *albifrons*, which is found, under closely similar environmental conditions, upon the adjacent mainland, and which probably represents the parent type from which *leucocephalus* sprang; and a dark form, *polionotus*, found in Alabama, Georgia and northern Florida. The last race is nearer, in several respects, to the more typical condition in the genus *Peromyscus*, and, if not actually ancestral to the various sub-

and red. On the other hand, a weak positive correlation is shown by the small Ono Island series; while in the third of these series, as already stated, the tail stripe is commonly lacking altogether.

[40] Amer. Nat., Apr.-May, 1918; May-June, 1923.

FIG. 10. Santa Rosa Sound and Santa Rosa Island, as viewed from Camp Walton, Florida. FIG. 11. Pine woods on north shore of island, showing prevalence of exposed white sand, even in this section. FIG. 12. Open country, prevalent in central and southern parts of island, in region visited by the writer. This sort of territory probably covers the entire width of the island throughout the western two-thirds of its length. FIG. 13. Sand dune, with scattered clumps of the "sea oats" (*Uniola paniculata*).

FIG. 14. LEUCOCEPHALUS, ALBIFRONS AND POLIONOTUS, PHOTOGRAPHED AGAINST A BACKGROUND OF WHITE SAND FROM SANTA ROSA ISLAND

UNIV. OF MICH.

FIG. 15. THE THREE RACES, AGAINST BACKGROUND OF SOIL FROM ALABAMA FARM, WHERE POLIONOTUS WAS TRAPPED

UNIV. OF MICH.

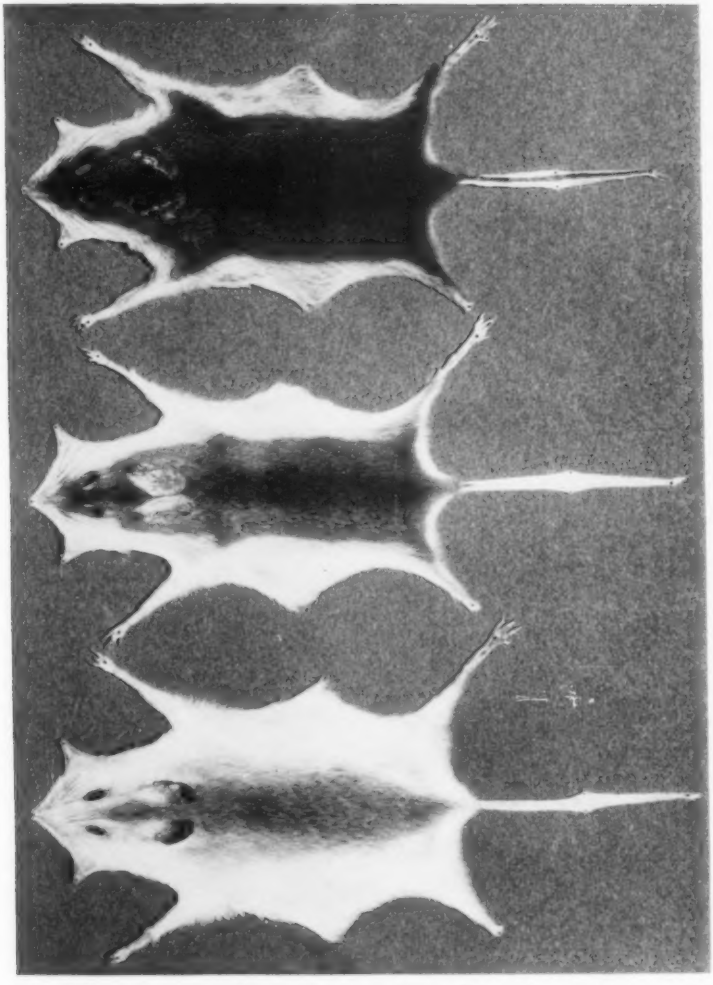

FIG. 16. SKINS OF TYPICAL SPECIMENS OF THE THREE RACES, PARENT GENERATION

Leucocephalus = serial no. 5079 of my series; *albifrons* = 5088; *polionotus* = 5010. In each case a skin was selected which was as near as possible to the mean in respect to all of the pelage characters here considered. The ears of *leucocephalus* and *albifrons* reverse, however, the more usual relation.

species of *P. polionotus*, it has probably departed less from the primitive condition than have any of these others.

The three races here considered agree closely in weight and in body length. They present considerable sexual differences in size, however, the females averaging larger than the males.

The races present characteristic differences in the length of the tail, foot and ear; and the foot, as in other species of *Peromyscus*, averages larger in males than in females.

The dorsal tail-stripe is fully developed only in *polionotus*. It is rudimentary or lacking (rarely of full length) in *albifrons*, and wanting altogether in *leucocephalus*.

The soles of the hind feet are frequently pigmented in *polionotus*, rarely and feebly in *albifrons*, quite unpigmented in *leucocephalus*.

In the dark race, *polionotus*, the hairs throughout the ventral whitish region are pigmented except near the distal ends. In *albifrons* and *leucocephalus*, much of the ventral and lateral hair is white from base to tips. Between this region of pure white hair and that of the dorsal region, which is pigmented from base to tips, is an intermediate zone of varying width, in which the hair is pigmented at the base only.

The extent of the pigmented region of the hair (as seen from the surface) is greatest in *polionotus* and least in *leucocephalus*, the condition in *albifrons* being intermediate. These areas have been measured with approximate accuracy by means of the planimeter.

Analysis of pelages with the tint-photometer shows that these races differ in shade (whether light or dark), and in purity of color (whether highly colored or tending toward neutral gray). They do not differ appreciably in the quality (spectral position) of the color itself.

Separate consideration of three very limited local collections of *albifrons*, taken in regions more or less isolated from one another, shows that these differ rather markedly, both in the extent and the shade of the colored area of the hair. The reality of some of these local differences seems highly probable, despite the small number of specimens available.

Correlations have been computed between various pairs of characters, these being mainly ones which differ in the three races. As in my previous studies, I find here no general tendency for the elements of the complex which distinguish one race from another to vary together within the single race. They may or may not do this. Thus, tail length and foot length, which have undergone parallel modifications in the evolution of some geographic races, are found to vary together in the same

direction, even when the influence of body size has been eliminated from consideration. And certain of the pigmental characters (though not all) are likewise rather strongly correlated with one another. On the other hand, neither tail length nor foot length appears to be correlated with any pigmental character.

The genetic significance of some of the foregoing facts will be considered in a later paper.

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NOTES ON THE ANTELOPES AND ZEBRA OF NORTHERN RHODESIA AND PORTUGUESE EAST AFRICA

By Wynant Davis Hubbard

From September, 1922, until April, 1925, I hunted over portions of Northern and Southern Rhodesia and Portuguese East Africa. My trips took me back and forth across the Batoka Plateau, up the Kafue River as far as Kayingu, to the Zambesi River about forty miles below the lower end of the Victoria Falls gorge, from Shamva overland to Tete, from Tete overland on the north bank of the Zambesi to Chiputo, and from Massanangwe by boat to Murracca. All told on various safaris I walked well over five thousand miles. During these three years I talked about animals with as many hunters both white and black as possible, kept notes and diaries and in general recorded as many facts regarding the mammals, birds and reptiles as possible. My business was capturing specimens alive and making moving pictures, as well as collecting in a small way.

The following notes on distribution, habits, numbers, calving times, and the like are some of the results of this work and are set down for what they are worth in the hope that they may prove of value. The most accurate records were kept during the last year, beginning at the time I started from Shamva for Portuguese East Africa. All measurements, unless otherwise stated, were made with a steel tape, following the rules set down by Doctor Hornaday in his book on taxidermy.

KUDU

On the Batoka Plateau in Northern Rhodesia the kudu is considered by competent and observing hunters to be, with the possible exception of the sable, the commonest of the antelopes. Owing to its habit of

feeding mainly at night and of frequenting the thickest and roughest parts of the country, it is not readily seen by the amateur hunter and is therefore commonly thought to be rare.

On a trip through the Mashakulumbwe country to Kayingu's village on the Kafue River, kudus were found to be numerous even on the sandy rolling country adjoining the flats themselves. At Kayingu's, which is in the Game Reserve, kudus were extremely numerous and their horns exceeded in numbers any others found in the village.

Along the escarpment mountains of the Zambesi Valley kudus were also very numerous and this seems to be true from Tete in Portuguese East Africa to the Victoria Falls on both sides of the river, except in swampy places.

During the year from April 1, 1924, to March 22, 1925, I had an average of five natives hunting for me continuously every day to supply meat for my camps. During this period one hundred and forty-nine antelopes were shot. Of these, kudus totalled thirty-seven and were the most numerous, exceeding the total of waterbucks, the next most plentiful, by two. Of these thirty-seven kudus, sixteen were cows and twenty-one were bulls. As would be likely when employing native hunters, the ages of the animals shot varied from immature to fully adult.

The five longest horns measured in a straight line from base to tip as follows: 47, 42.75, 42.38 and 38.5 inches.

Of the sixteen cows shot the following facts were noted. On August 17, I shot a large kudu cow which had a calf running with her which measured exactly four feet high at the shoulder. This calf was still nursing, as was evidenced by the full udder of the cow which contained at least a cup of milk. On December 1, I shot another cow which had no calf with her but which carried a foetus measuring twenty inches from nose to root of tail and which stood about ten inches high at the shoulder. On January 10, I shot two more cows which carried large fully developed foetuses which I judged would be dropped within three to four weeks. These cows were fully adult and were accompanied by calves of the previous season. There were no bulls excepting the male calves.

The largest herd which I have seen and counted numbered eighteen individuals. I have seen many other herds numbering from three to fifteen animals so I doubt very much if kudus ever run in herds of over twenty-five individuals.

A fact which I have not noticed recorded before is that the stripes on

a kudu vary in number. In one series of skins which I examined I found that the stripes varied in number from eight to eleven and that this was unrelated to sex, cows and bulls varying indifferently. Also the color of the skin varies from tannish brown to a gray, bluish brown. This variation is, however, a sign of the age of the animal. The older the animal is, the grayer and darker and more nearly hairless is its coat. In the old bulls the neck is almost hairless except for the manes, and the body is dark blue-gray, with a slight hint of dark brown and indistinct stripes.

From the number of skulls which I have found and from a close observation of animal life in the bush, I do not think that lions kill many kudus, speaking comparatively. Kudus are extremely fast runners, particularly in thick bush, and are very alert and nervous. I once had a kudu cow pass within ten yards of me when she was badly frightened, and I was greatly astonished at the speed she developed.

Summed up my observations on the kudu are:

1. That kudus are perhaps the most numerous of the large antelopes on the Batoka Plateau and in the Zambesi Valley from the Victoria Falls to Murracca.
2. Average bull horns measure about forty inches.
3. Kudus drop their calves from the middle of February to the middle of March.
4. Gestation period is about four months.
5. Stripes vary in number from eight to eleven regardless of sex.
6. Color is an indication of age, young kudus being brown with very white stripes, and old bulls bluish gray with indistinct stripes.
7. Kudus are very fast runners, live in thick bush, feed preferably at night, and are comparatively speaking not greatly preyed upon by lions.

COMMON WATERBUCK

During one year thirty-five waterbucks were shot. This number, ranking next to that of the kudu as the most plentiful, does not give a real idea of their numbers as compared with other antelopes. In Portuguese territory near the rivers among the hills they were very plentiful. On the Kafue and Zambesi in Northern Rhodesia they were also numerous, but on the rolling plateau between these rivers they were scarce. I think that in total numbers they were not so numerous as sable antelopes, but they ranked very close.

The five longest pairs of horns measured as follows: 28.5, 26.5, 23, 22.5 and 21.5 inches.

From the records of the sixteen cows shot the following facts appear. A cow shot August 27 carried a small foetus. One shot in October carried a foetus of medium size and one shot towards the end of November carried a well developed and fully formed foetus. In August, a young waterbuck calf standing about four feet high was still drinking milk, but was also beginning to eat tender grass and shoots.

Waterbucks run in herds of about the same size as kudus. Cows are accompanied by calves and also by the adult bulls. Contrary to my observation of kudus, single waterbuck bulls seem to be the exception. Almost every adult bull has a herd of cows together with a few immature bulls and calves.

Like the kudus, waterbucks escape the attention of lions to a great extent. This is probably due to their ability to run fast among rocky kopjes and to climb very rapidly. While they prefer rough, rocky country near water, I have found waterbucks on sandy flat stretches in mopani bush country. They are never found more than a few miles from a plentiful supply of fresh water.

Summed up the observations on the waterbuck are:

1. These animals are very numerous on the upper middle Kafue and on the Capoche, Luia, Ruia and Zambesi rivers in Portuguese East Africa. They rank in numbers next to the kudu and the sable antelope, perhaps exceeding the latter.
2. Average adult horns measure about twenty-five inches.
3. Waterbuck cows drop their calves from the first to the end of December.
4. Gestation period is a little over four months.
5. Waterbucks are fast, good climbers and runners on rocky ground. They are always found near water. They are not greatly preyed upon by lions.
6. The hair of young calves is long and more silky than that of adults and the white ring on the rump is indistinct. In old bulls the hair becomes very stiff and thins out.

ELAND

Elands are nowhere as common as they are reported to have been in the '70s and '90s. I found them most numerous on the sandy rolling country adjoining the Kafue Flats and on the edges of the flats themselves. In Portuguese East Africa I have seen elands along the Ruia and Mazoe rivers and on the Capoche and Luia, but not near the Zambesi. The country close to this last river is too rocky and hilly for animals of their weight and bulk.

Of nineteen elands shot, twelve were cows and seven bulls. Bulls' horns measure as follows: 27, 27, 25.5, 25, 19.5, and 18 inches. Cows' horns: 27.25, 26, 25, 25, 24.5, and 23.5 inches.

In old bull elands the horns become very worn away and as a result the huge, black-faced bull of great age does not carry long horns, but rather short, massive stumps. There are two distinct types of horns, those curving outwards at the tips and those curving inwards. Cows' horns are slighter than those of bulls and are often malformed.

From my records of the twelve cows the following facts appear. Two eland cows shot on January 9 carried no foetuses. One was a very young cow with horns measuring only 11.5 inches; the other was large and fully adult. A cow shot on December 12 carried a small foetus and another shot on December 18 also carried a small foetus. One shot on February 20 carried a very large and fully formed foetus which would have been dropped within three weeks.

Elands occasionally run in herds of as many as forty individuals. The size of the herds seem to be governed largely by the type of country. In flat well-watered and grassy country the herds are large. In stony country the herds are small, rarely exceeding twelve individuals.

Lions prey upon elands to a great extent, as is evidenced by the large number of skulls found. Also it is exceptional to shoot an old, black-faced bull without finding the marks of the teeth and claws of lions on its neck. From what I have seen I should say that lions often attack these slow-moving bulls, but that they are rarely able to kill them. Their ponderous weight and great strength, as well as the great thickness of the hide on their necks are more than the lion can overcome.

The observations of the eland sum up to this:

1. They are plentiful on the flats and rolling country of the upper middle Kafue and are found scattered over most of the plateau of Northern Rhodesia. Elsewhere in Portuguese East Africa and in the Zambesi Valley they are found in small herds wherever the country is not too rocky or hilly.

2. Average bull's horns measure 26 inches; average cow's horns measure 25 inches.

Cows' horns are slighter than those of bulls and are often malformed. Those of very old bulls are usually very much worn away and are stout and heavy.

3. Cow elands drop their calves in March.

4. Gestation period is about four and one-half months.

5. Elands are slow runners, but they can keep up a smart canter for

miles. They prefer rolling grass-covered country to stony hilly country. They are preyed upon by lions to a great extent, but old bulls seem to be strong enough to withstand the attacks of lions.

6. Young elands are bright tannish color with very white stripes. Old bulls become very nearly hairless on the body, the stripes fade out and the hair on the face becomes very long, thick and matted.

LICHTENSTEIN'S HARTEBEEST

It is very difficult to form an estimate of the number of hartebeests. My records show that during one year twelve were shot, but as they are one of the most alert and wide-awake of antelopes the number shot affords little indication of the total number. Particularly is this so as these records are for a country not usually recognized as particularly suited to the needs of hartebeests.

I know of only one spot in which hartebeests occur in the Zambesi Valley between the Victoria Falls and Murracca, this being on the flats along the Revubwe River opposite Tete in Portuguese East Africa. On the plateau of Northern Rhodesia one meets with them almost everywhere, but always in small herds of less than a dozen. Along the Kafue Flats and their many ramifications hartebeests are fairly numerous.

In Portuguese territory they are to be found on the Luia and Capoche rivers and on the Revubwe, but they are far from plentiful. Between Shamva and Tete I have no records of having seen any traces of them, nor do I recollect the natives having mentioned them as occurring in that area.

Of the twelve hartebeests shot, seven were bulls and five cows. Bulls' horns measure as follows: 15.5, 15, 14.5, 14.5, and 12.5 inches. Cows' horns: 14, 11.5, 10.5 and, 10 inches.

I have an accurate record of only two cows. One shot August 19 was carrying a well formed foetus. Another shot on September 18 had dropped its calf just a few hours before, as was evident from its exhausted condition and the state of the vagina. Incidentally I never saw the calf as it went off with the herd upon my firing the shot. From this I would say that young hartebeests can run very swiftly within a few hours after birth.

Lions attempt to kill hartebeests very often, and while they occasionally succeed I do not think that they kill as many of this species as they do of the eland. Hartebeests are light weight and once a lion gets hold of one it is probably done for, which is by no means always

true of an eland. As hartebeests are among the fastest of antelopes, usually feed in open country, and are very cautious and watchful, I do not think that they are often subjected to the attacks of lions.

My notes on Lichtenstein's hartebeests sum up as follows:

1. Lichtenstein's hartebeests are fairly plentiful on the borders of the Kafue Flats and are to be found all over Northern Rhodesia excepting in the Zambesi Valley. In Portuguese territory they are to be found on the Ruia, Capoche and Revubwe rivers. I have no record of them occurring in the country lying between Tete and Shamva.

2. Adult bulls' horns average a 14.5 inches; adult cows' horns average about 12 inches.

3. Hartebeest cows drop their young in September at the beginning of instead of during the rainy season as is usual with most antelopes.

4. Hartebeests are extremely fast runners, very wide-awake, feed in open country and are not greatly preyed upon by lions.

5. Young calves are grayish tan, the white rump being indistinct. Adults are bright tan with a mahogany-colored back.

ROAN ANTELOPE

The roan antelope is a splendid animal, full of courage and afraid of practically nothing except man. Often, unfortunately, he is not enough afraid of the latter. I have encountered roan antelopes everywhere; from the Kafue to the Zambesi in Northern Rhodesia and from Shamva to Tete and on up to Chiputo they were to be found everywhere. I have never seen a large herd, seventeen is the maximum, but they are numerous nevertheless.

From the records of nine shot, five were cows and four bulls. Unfortunately I have no records showing when roan antelopes drop their calves, but I am pretty certain that it is in September and October, as with the sable antelope.

Horns of the animals shot measured as follows: bulls, 24.75, 24, 21, and 21 inches; cows, 21.5, 20.5, 18, and 10.75 inches.

SABLE ANTELOPE

This magnificent antelope is found at its best on the Batoka Plateau, and from there it spreads everywhere, and is found in greater or lesser numbers over most of Northern Rhodesia and the interior of Portuguese East Africa where I have been.

Occasionally one finds sable antelopes in herds of as many as forty

individuals, but more often the numbers are around fifteen. The old, black, fully adult bulls run by themselves either singly or in parties of two or three. I once came upon seven such bulls feeding together. The bulls running with the herds are rarely black.

From close observation it is my opinion that bull sable antelopes do not attain their complete black and white coats until they are between the ages of five and seven years. Why these older bulls separate from the herd I do not know, as individuals of this species rarely seem to fight among themselves. I have only once come on evidence of fighting and this was merely torn-up ground covered with the tracks of two adult sable bulls.

Of four sable antelopes shot during the year beginning in April, 1924, two were bulls and two cows. The horns measured as follows: bulls, 35 and 31.5 inches; cows, 27.5 and 27 inches.

I have no record of ever having shot a sable cow carrying a foetus. But in my operations I have often had young sable antelopes brought to me for sale by the natives. These were always youngest and most plentiful in October and November, so I judge that, like roan antelopes and hartebeests, sable antelopes drop their young at the beginning of the rainy season.

IMPALLA, BUSHBUCK, DUIKER AND GRYSBOK

I group these four of the smaller antelopes together as unfortunately my records concerning them are not complete.

Impalla are found in numbers on the edges of the Kafue Flats and in the Zambesi Valley. I do not recollect having seen or heard of them as occurring on the Batoka Plateau proper.

Five pairs of impalla rams' horns measured as follows: 19.5, 19, 18, 16.5, and 16.25 inches.

The common duiker is found everywhere. The only note of interest which I have concerning it is of one specimen, an ewe, which I shot between the Ruia and Capoche rivers in Portuguese East Africa. The hair on the face of this ewe was very red and it had a marked tuft of reddish and black hair standing straight up on the top of its head between the ears. Otherwise it was marked as other common duikers. This reddishness was so very pronounced and so unusual that I made a special note of it.

Ram duikers' horns measure as follows: 5, 4.75, 4.75, 4.70, and 4.25 inches.

Bushbucks are extraordinarily plentiful on the Ruia and Luia rivers

of Portuguese East Africa. They are also found all over Northern Rhodesia and the other parts of Portuguese East Africa that I have hunted over wherever there were patches of thick bush in which they delight. I have shot only two in my three years of hunting, but that is because when I was hunting in the thickets where bushbucks abound I was after elephants. Both of the bushbucks were males. The horns measured 11 and 16 inches respectively.

Leopards are very fond of preying upon bushbucks. Often at night I have heard leopards as they stalked the thickets where the bushbucks were. Also leopards are very fond of impallas. These antelopes fall a prey more often than the bushbucks as the latter are very aggressive and full of resources. The main reliance of impallas seems to be their wonderful leaping powers and quick dodging. They are utterly non-aggressive.

Grysboks are the hardest of antelopes to study. In habits they are more nearly like rabbits than any other antelope. They have the same habit as a rabbit in lying still until one almost steps on them, when they bolt, insanely dodging from side to side as they go. A sharp whistle will often bring them to an instant standstill, even when in headlong flight. Grysboks are not nearly as plentiful as duikers, but they are still a common, though rarely noted, antelope.

I once came on the remains of a grysbok which had been killed by a lion, which goes to show that no animal is really free from the attacks of these huge carnivores.

Of the other antelopes I have come into contact with I make no notes here as I have no definite records other than distribution and numbers. Suffice it to say that I have either shot, hunted, captured or handled the following other species: Blue wildebeeste, lechwe, puku, reedbuck, oribi, steinbok, klipspringer and sitatunga.

ZEBRA

On the Kafue Flats zebras run in large herds, associating with blue wildebeestes. They are also found in many parts of the Batoka Plateau, in the Zambesi Valley and scattered over most of the country between Shamva and Tete, and Tete and Chiputo.

In the Zambesi Valley near Masanangwe I found zebras numerous, but, curious to relate, that they preferred spending the daytime lying down on the very tops of the steep stony hills which abound in this area. These hills are two and three hundred feet high, scantily covered with grass and very stony, but the zebras were always to be found on the tops of them.

Of fourteen shot, ten were mares and four stallions. One shot on July 27 carried a foetus which was well developed and fully formed and which would have been dropped within two weeks. On September 4, I captured a foal which stood not quite four feet high at the shoulder and which was still drinking milk. The milk was thin and blue, and I subsequently had no difficulty weaning the foal within a very short time.

On the whole my impressions of the antelopes and zebras of Northern Rhodesia and Portuguese East Africa are these: Probably there are fewer antelopes and zebras than formerly, but they still remain in great numbers. Their greatest menace is not the white hunter, but the native armed with gun and dogs who knows no closed season nor has any thought of the future. The hunting native armed with a gun kills on an average five head of game a week! Control these hunters and then, with the aid of laws made with an exact appreciation of the relative numbers of the game animals as well as their total numbers, the game of Africa will last for a great many decades yet.

Staten Island, New York.

THE HABITS OF MICROTUS MINOR IN MANITOBA

By Stuart Criddle

The observations upon which this paper is based were made in the vicinity of my home near Treesbank, Manitoba. They were commenced several years ago and have been continued whenever opportunity offered. Marked assistance has been given by my brothers Evelyn and Talbot, and particularly by my brother Norman who often accompanied me on my rambles in search of information.

The species *Microtus minor* Merriam is one of those unobtrusive rodents that occurs over a wide range of territory, including southwestern Manitoba, but which, on account of its retiring habits is not so often seen as are some allied species. In reality it is among the commonest of our field mice and once its habits are known it can not be mistaken for any other species found in our territory.

The habits of these voles, or field-mice as they are often called, are subject to distinct seasonal changes which are so definite that it has been deemed advisable to group them so that they coincide with the periods of the year in which they occur, as follows: Summer, the time of breed-

ing; autumn, the time of building and storing; and winter, the time of minimum activity or rest.

SUMMER HABITS

The summer habits begin in the spring when the voles leave their winter abodes which have harbored them for approximately eight months, the actual date being determined largely by weather conditions and food supply. It usually occurs, however, early in May. On leaving their winter quarters the voles scatter in various directions and whereas they were gregarious in habits they now become semi-solitary. Suitable breeding sites are located and in these nests are built and the young reared. Burrows of pocket gophers (*Thomomys* sp.) are most favored as nurseries, although any hole of suitable size, or even a bunch of hay, may be utilized for the purpose. The rodents now become very quiet and secretive. Indications of their presence may be found in the newly cut shoots of tender vegetation and the signs that dead leaves have been gathered for a nest. It seems strange that the winter quarters are not more frequently used for breeding purposes, but while there is occasional evidence of such an occurrence, yet of nearly a hundred winter dwellings examined in summer time, only one was found in use. As this exception constitutes also the earliest breeding record by nearly two weeks, the facts are given in detail as follows: On May 2, 1924, two voles were seen to run from a winter residence which had just been ploughed up; on being captured they proved to be a male and female, and in the nest were two young six or eight days old. The nest was in a field on which rye had been grown the previous year, and the fact that the animals had abundance of grain to feed upon may have induced this early breeding.

Judging from our records the usual time for the first young to be born is between May 15 and June 1, the number in a litter ranging from one to eight. The evidence available indicates that at least five litters are reared during the summer. The latest record of young being nursed is September 30, on which date a female was discovered beneath a wheat stook from which she darted with a young one, some four or five days old, hanging to a teat. This vole had made a small temporary nest of wheat leaves. From the fact that these animals usually begin building their winter homes some time before this date it is believed that the litter in question was an exceptionally late one.

The summer food apparently consists entirely of green vegetable matter of which *Artemisia dracunculoides* seems to be particularly favored.

We have found no indications of root-digging during the breeding season.

AUTUMN HABITS

As the rearing season draws to a close the habits of *Microtus minor* undergo a remarkable change. The semi-solitary mode of life is abandoned and the animals gather together in colonies to prepare for winter. It is impossible to state definitely whether these communities really consist of the young of a single mother or of all the individuals within a certain radius gathered together for mutual protection. There is little doubt, however, that more than one family occupies each winter home.

The site for winter quarters, which appears to be selected with considerable care, is usually amid thick grass, or near shrubs or small trees. Situations are chosen that present the greatest amount of cover for the home and runways, and also where food for storage is plentiful.

Having selected a situation for building, the voles first dig out a large excavation for the nest and make runways around it. As work advances, tunnels are dug away from the nest chamber and material is taken in. The building of the nest itself is a work of much skill. The material gathered consists almost entirely of a small prairie sedge (*Carex* sp.) and is selected with interesting discrimination. Entire leaves are used for the outer part of the nest, but as construction proceeds towards the center the leaves are split up into fine shreds, thus providing an insulated nest which is doubtless exceedingly warm and comfortable.

While still constructing the nest, the animals dig several main tunnels and begin the store chamber which is situated from 10 to 20 inches from the nest. All the excavated earth from the main chambers, tunnels, and partly sunken runways is carefully placed over the residence, thus forming a roof which answers the double purpose of shedding rain and keeping the home warm. Runways are next pushed out in all directions, the main ones usually following the thickest vegetation so that their builders may readily dart along them without being detected by enemies above. The main runways, which are generally three or four in number, are gradually lengthened as the search for food extends farther afield. They are quite intricate in their ramifications and have been known to extend 351 feet from the dwelling. There is abundant evidence to show that the voles also continue their activities in search of food for a considerable distance beyond their runways.

The storage of food is begun as soon as the storehouse is sufficiently

advanced in construction to receive it, the chamber being enlarged as required. In a few cases second store rooms have been provided after the first became stocked. These were always situated on the opposite side from the original one. There is much variation in the size of the store chamber, depending largely on the number of inhabitants present and partly upon the quantity of food in the vicinity. Following is a description of an average sized home from which seven voles were captured: Outside circumference 14 feet 3 inches; nest, slightly north of center, circumference 29 inches; depth from top to bottom, 33 inches. Nest material prairie sedge, the interior portion of finely divided leaves. Store chamber unfinished, length 14 inches; width 9 inches; depth 5 inches; top of store chamber approximately 2 inches below the surface; distance from nest 16 inches. There were five entrances from outside, which united with the main tunnels that led to the store chamber. Hence it is evident that all supplies had been taken into the home through the entrances of the main runways and so along the intricate underground passages to the store room to which there was no direct entrance from above. There were three main runways leading from the home for a distance of approximately 260 feet, and a ramification of minor roads branched off from them. The contents of the store room were as follows: *Liatris punctata* bulbs, 39 per cent; wheat heads, 29 per cent; *Juniperus horizontalis*, berries and galls, 7 per cent; *Allium stellatum*, bulbs 6 per cent; *Psoralia esculenta*, *Helianthus rigida* and *Artemisia dracunculoides* 2 per cent each; unidentified roots, 3 per cent. Total weight 19¾ pounds.

Another home dug up in a grass field on low-lying land contained the following roots: *Taraxacum erythrospermum*, 85 per cent; *Convolvulus sepium*, 13 per cent; *Sisyrinchium angustifolium*, 2 per cent. Total 3 gallons, weighing 24½ pounds.

Still another dwelling situated in a small isolated poplar bush, contained the following percentages of stores: *Liatris punctata* 37; *Allium stellatum*, 31; *Geum triflorum*, 17; *Solidago missouriensis*, 7; *Juniperus horizontalis* galls, 1, and a few other unidentified roots, the whole weighing 17½ pounds. This home was dug out on November 9; only one vole was captured although there were undoubtedly others in hiding. The store was left on top of the ground and when revisited three days later, it was found that the food had been removed to a new situation, probably to a pocket gopher burrow close by. The newly fallen snow, however, made exact location difficult.

Among the many homes examined, one dug up near a garden on

November 23, 1924, was of particular interest in that it showed how much mischief these animals can do when left undisturbed. The stores in this abode were made up as follows: Artichoke tubers, 9 pounds 11 ounces; tiger lily bulbs, 5 pounds 8 ounces; ripe garden peas, 9 ounces; *Allium stellatum*, 8½ ounces; *Helianthus* roots, 8 ounces; *Taraxacum* roots 1½ ounces, *Liatris* 1 ounce; the remaining 7 ounces consisting of roots of *Artemisia*, *Aster*, *Solidago*, *Sisyrinchium* and *Calamovilfa*, making a total of 17 pounds 5¼ ounces. Nine voles were taken from this dwelling which had been under observation for about two months. The animals are easily trapped and it is, therefore, quite unnecessary to permit depredations such as these.

The examples given are representative of the average stores, but there is a good deal of variation in different localities, the food plants which dominate invariably forming the bulk of the stores. This is demonstrated by the contents of the store chambers in different habitats given below: Rye field; rye heads 94 per cent, roots 6 per cent, total 2½ gallons. Oat field; oat spikelets, 93 per cent, roots 7 per cent. Beneath oak; acorns 83 per cent, roots 17 per cent.

It should be noted that *Microtus minor* is not of very marked importance from an agricultural standpoint. The grain taken is nearly all gathered from the ground and, therefore, of little account, while the raids on gardens are only casual and can easily be checked. Unlike the red-backed vole, this species does not feed on bark and in no way injures trees. Perhaps one of its most interesting food habits is that of digging up dandelion roots, which it does so thoroughly that the plants are entirely destroyed. This vole has also a rather marked influence on certain wild flowers such as *Liatris* and *Allium*, though this is hardly noticed owing to the abundance of these plants on the prairies.

The numerous exit holes mentioned as provided to the winter homes appear to be constructed largely for the purpose of protection against enemies such as badgers, skunks and the larger weasels. The runways enable the voles to escape readily in the herbage, from which they return when all danger has passed.

The winter food is always of vital importance and its removal invariably results in the death of the owners from starvation.

WINTER HABITS

The winter habits of *Microtus minor* commence with the first really severe frost, when the ground becomes frozen too hard for further digging for roots. This occurs, on the average, about November 7.

The following notes are from observations made during the winter of 1920–21.

Four homes were under special observation and their occupants all went into winter quarters on October 28, hard frost at this time putting a stop to outside activities. The animals came out daily, however, until November 9, but as the weather grew colder they became less active. Snow on November 10 and 11 checked their movements still more, and after this date they took only casual ventures outside. On December 6, the temperature fell to 6 degrees Fahrenheit and the burrows became blocked with frost and there was no further outside activity until January 5, at which time the temperature rose to 25°. The tunnels were then opened for a distance of about 6 feet. The animals also came out on the following day from two homes, one of them being captured tunneling just beneath the snow. During the warm spell of three days the rodents continued their activities, one of them travelling 137 yards on the snow, the tracks indicating a trotting, rather than a jumping, motion. The following notes are taken directly from my journal:

January 10, temperature zero. All outside activities temporarily at an end.

January 28, maximum temperature 33°. Voles out of homes one and three.

February 3, residents of homes one, two and three have been out for a short time each day since January 28, but as usual were less active when the temperature fell below zero. Wheat, oats and rye were placed near the homes and a small quantity of this grain was taken into the burrows together with some suet. Considerable tunneling was done at this time in the snow close to the ground but 11 inches of it made exact observation difficult.

February 14, voles in home number 1 had been out daily since last report, using only two exits. They emerged on one occasion with the temperature 20 degrees below zero.

February 28, midday activity has occurred intermittently in home number 1, a single exit being in use until the eighteenth, when another was opened.

March 10, cold since last report. Slight activities were discernible in home number 1, but not in any other.

March 20, voles much more active outside, especially from home number 1. Tunnels have been made extending 45 feet, and a network of minor burrows constructed in the snow around the home, in addition to numerous tracks made on top of the snow.

March 27, voles in home number 4 show activity for the first time since December 5.

April 1, the occupants from all four homes have been out and there has been some work on old runways but there are no indications of food having been gathered.

April 4, snow nearly all melted. Several additional vole homes have been inspected, all of which showed evidences of outside activity at various times during the winter. In the majority of cases the animals had gone outside for sanitary purposes, although the empty store chambers had been freely used in this connection.

On April 10, four homes were examined around which were no indications of winter activities. A few runways had been recently renovated but there were no signs of food having been taken in. Two of these homes were opened despite the frozen ground. In one, five voles were captured, four of which were females; all proved to be in good condition, and the nest was perfectly clean and dry, but little food remained in the store chamber. In the other only one animal was found and the abundance of food remaining indicated that disaster had overtaken some of the occupants.

A home opened on April 20 contained four voles, three of which were females. The store room was empty and the inhabitants had been foraging for young shoots of grass and weeds. All homes examined after this date, with one exception, were deserted.

NATURAL CONTROL

It is well known that rodents fluctuate in numbers and that they have their periods of abundance followed by others of rarity. As a rule the causes for this fluctuation are imperfectly understood and it is interesting, therefore, to be able to shed light upon the problem as revealed through the study of *Microtus minor*.

In 1922 this species went into winter quarters in great numbers and its homes were well stocked with provisions. Three homes were under special observations in which all went well until the middle of February, 1923. Then, within a few days, each was taken possession of by a least weasel (*Mustela rixosa*) and the inhabitants were quickly destroyed. One dwelling was occupied by one of these weasels for about two weeks during which time I observed that it had dragged several mice over the snow to its temporary home. This residence was examined in April, and in it were discovered six dead *Microtus minor*, one *Evotomys*, the head of another, and at least six or eight remnants of small rodents

including *Microtus drummondi*, these last remains being chiefly indicated by the hair-lined nest of the weasel.

The homes of 27 other vole communities examined at this time were all found to have been entered by weasels, the inhabitants having been killed and partly eaten. Moreover the weasels had made the homes temporary centers from which they raided other rodent habitations in the vicinity. Thus from being an abundant animal this vole was reduced to insignificance in the course of a few weeks, while all other kinds of mice had suffered severely from the same enemy.

Hawks, owls, skunks, badgers, foxes and coyotes all prey upon these voles. The badger is often particularly destructive to them, on account of its habit of digging out the nests late in the fall when the builders find difficulty in reconstructing them. All our weasels are eminently mousers, but it is the least weasel that is the natural enemy of *Microtus minor;* being so small it can readily follow the rodents through their runways into their homes, and once in possession it speedily overcomes the occupants.

Treesbank, Manitoba.

THE BULL SNAKE AS A NATURAL ENEMY OF INJURIOUS RODENTS[1]

By Frederick L. Hisaw and Howard K. Gloyd

It has for some time been a well known fact that the bull snake, *Pituophis sayi* (Schlegel), preys upon small mammals, but its value as an important factor in the control of noxious rodents by their natural enemies has received too little emphasis. The lack of appreciation of the beneficial qualities of this large reptile may be due largely to an innate aversion to snakes of all kinds which many people unfortunately possess. It was brought to the attention of the writers, while making a study of the pocket gopher, that several large bull snakes under observation had wounds or scars along the sides of their bodies which appeared to have been made by the teeth of rodents which they had captured. This paper presents the results of some of the investigations which followed.

[1] Contribution No. 79 from the Department of Zoology, Agricultural Experiment Station, Kansas State Agricultural College, Manhattan.

LABORATORY CONDITIONS AND METHODS

The bull snake is a very gentle and tractable species which usually adapts itself quite easily to laboratory conditions. About forty snakes were under observation for a greater or less period of time. The majority of individuals took food readily within a day or two after capture. They were kept in large, roomy cages with three to six inches of earth in the bottom and had the benefit of direct sunlight for a short time each day. The animals used as food were chiefly rats which were weighed and placed in the cages with the snakes. Food was usually taken promptly and differences in size, color pattern, and other characteristics made it possible to individualize the specimens and determine which had made the capture. The snakes were not allowed to become gorged with food; an effort was made to keep them in such condition that they would consume about their normal amount.

FIG. 1. A BULL SNAKE KILLING A POCKET GOPHER. DRAWN FROM PHOTOGRAPH

METHODS OF CAPTURING PREY

The bull snake kills its larger prey by constriction. Smaller and weaker animals are simply swallowed alive. When an adult pocket gopher or rat is placed in a cage, the snake approaches it very cautiously from the side with its head slightly raised. As the gopher or rat passes, the reptile strikes it a savage blow, usually at the side of the head, seizes it in its mouth, and rapidly coils about it. The blow usually throws the victim off its feet and as it turns on its side or back the first coil of the snake's body is looped about it. Other coils are added in proportion to the size of the animal captured. After the tightening coils are in

place the snake may release the victim's head. All of this takes place with such rapidity and the constrictions are applied so vigorously that the snake is seldom bitten (fig. 1). When no signs of life remain in the captured prey, the pressure of the coils is very gradually relaxed. Simulating movement in the dead animal will cause the snake to renew the tension in the constricting coils very promptly. When satisfied that the captive is dead, the snake releases its hold, seeks the anterior end, and begins swallowing.

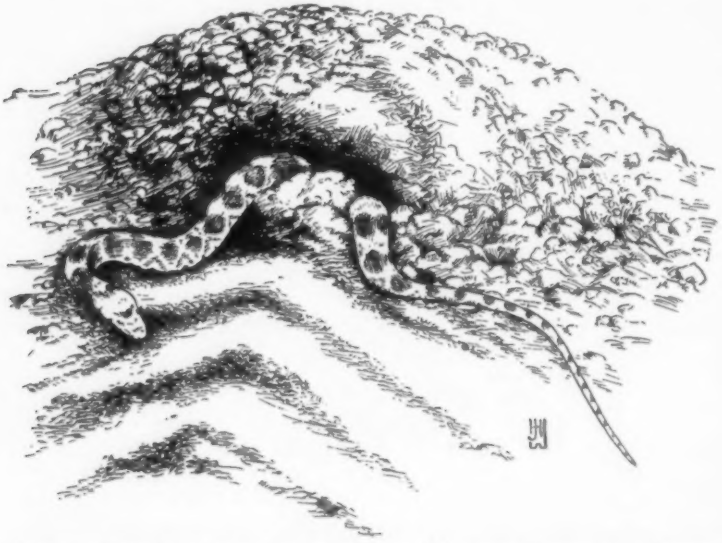

FIG. 2. A BULL SNAKE REMOVING EARTH FROM A LATERAL TUNNEL OF A POCKET GOPHER'S BURROW. DRAWN FROM FIELD NOTES

The bull snake is also an active and efficient burrower and apparently is able to capture burrowing rodents in their subterranean tunnels. In several instances burrows of the pocket gopher were found which had been opened from the outside. The excavated earth had been piled in concentric ridges (fig. 2). The animal responsible for this unusual circumstance was unknown until a bull snake was seen in the actual performance. In all cases observed in the field, the burrow had been opened where a fresh mound had been made and the soil was yet

loose. The pocket gopher constructs a mound by bringing soil from the main runway, which is horizontal to and from four to twelve inches below the surface, through short lateral tunnels which open at the surface. After the excavation is complete the lateral tunnels are filled with loose earth. Bull snakes have been observed digging the earth from lateral tunnels by pushing their heads into the soft soil and bringing it to the surface, a load at a time, in coils of their bodies. The burrowing process has also been observed many times in the laboratory.

Although the conflict which takes place when a bull snake enters a pocket gopher burrow was not observed, a process which may be essentially similar has been studied in the laboratory. When a snake attacks a small animal in a narrow space, such as between a box and the wall of its cage, instead of employing its coils in the usual manner, it attempts to compress its prey against one of the walls of the confine. The lateral pressure on the captive is obtained by three curves of the snake's body,

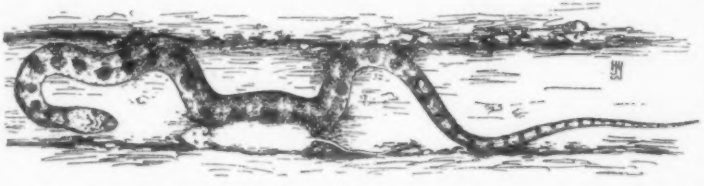

FIG. 3. SHOWING METHOD OF KILLING A RAT IN A NARROW TUNNEL. DRAWN FROM NOTES

one against the animal being killed, and one anterior and one posterior to this point on the opposite side of the narrow space (fig. 3).

The power of sight of the bull snake is apparently somewhat limited. Though used in capturing prey, it is not essential. A snake is very sensitive to contact stimuli and in the dark recognizes prey very readily by this means. If, when in the act of killing a victim by use of the coils, another animal comes in contact with the snake's body, it is at once pressed against the side of the cage or constricted by another series of loops. A single snake has been known to kill as many as three half-grown rats in this way at one time.

RELATION OF ECDYSIS TO FEEDING HABITS

It was also observed that the bull snake has a cyclic activity which includes feeding, fasting, and moulting. This is apparently repeated about every thirty days. The snakes under observation ate more

readily soon after shedding the skin and became more and more reluctant about attacking prey as the cuticle over the eyes became opaque. Four or five days before each moult they usually refused food and showed nervousness by retreating to a far corner and giving vent to their characteristic explosive hissing when a live rat was placed in the cage. Some of the snakes that had been in captivity for a longer time could be induced, just before moulting, to eat young rats that were held in front of their noses. It is quite doubtful if in nature they eat at this time.

TABLE 1

Amount of food eaten by ten bull snakes

ANIMAL	WEIGHT	TIME FED	MOULTS	FOOD EATEN
	grams	*days*		*grams*
1	1,410	38	2	960
2	1,130	46	2	1,388
3	945	98	3	1,780
4	1,082	62	1	770
5	585	91	2	1,020
6	953	152	5	1,685
7	1,270	197	7	3,349
8	365	31	1	168
9	690	31	1	246
10	998	13	1	499

POTENTIALITY AS A DESTROYER OF RODENT PESTS

The amount of food which a bull snake is able to consume, and which those of this species normally do consume, is of much significance in connection with the value of the species as a natural enemy of harmful rodents. The data given in the accompanying table present some interesting information on this point. The ten snakes here mentioned were chosen as most representative of the series. In general, they were the individuals under observation for the longest period of time.

If the weight of the food eaten is compared with the average weight of the small mammals found associated with the bull snake in its natural habitat, a basis for estimating the importance of the snake can be obtained. The average weight of fourteen adult pocket gophers, seven males and seven females, was found to be 287 grams. According to this, snake No. 7, which weighed 1270 grams and ate 3349 grams of food in about six months, would be capable of consuming about twelve adult pocket gophers in the same time. This approximately covers the

annual period of activity for these reptiles, which means that it is possible for each snake of this size to consume twelve of these animals each year.

These data also lend themselves to an economic consideration. Considerable information on the damage caused by the pocket gopher to the alfalfa of Kansas was obtained by Mr. Percy L. DePuy while he was working in connection with the United States Department of Agriculture, Bureau of Biological Survey. His estimate was based on several hundred answers to inquiries concerning the matter, which were sent to farmers. From this it was concluded that two dollars and fifty cents per acre is a fair estimate of the loss due to the ravages of these rodents. The average number of pocket gophers per acre of alfalfa of moderate infestation is about eight. A bull snake the size of No. 7, which was about five feet long, has the potentiality of destroying annually all of these animals on one and one-half acres. Pocket gophers are relatively large rodents so it would be possible for the bull snake to eat many more individuals of a smaller species of mammal, and there is little doubt but that this snake is important as a natural check on the entire rodent population.

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THE EXTENSION OF RANGE OF THE NINE-BANDED ARMADILLO

By John K. Strecker

I have long been committed to the belief that the northern variety of the nine-banded armadillo, *Tatu novemcinctum texanum* Bailey or, according to Hollister, *Dasypus novemcinctus mexicanus* Peters, has materially extended its range within the past four or five decades. I will here present the reasons for my belief, as well as such data as I can give in support of them. A considerable period of time has elapsed since the publication of Vernon Bailey's report on the biological survey of Texas (1905) and some of the data which I shall expect to present as new may already be in possession of other mammalogists.

In a residence of more than thirty-five years in Texas, I have been more or less actively engaged in studying its fauna. I have travelled through the majority of its counties and have collected specimens and made notes in many of them. Whenever I have had an opportunity to spend more than a day or two in any one locality, I have made inquiries of the residents regarding the occurrence of certain animals. Of course, the information received in response to my queries was indefinite when it referred to species whose positive identification could only be made certain when the actual specimen was in hand, but in the case of so peculiar and conspicuous an animal as the armadillo, even an intelligent layman is qualified to give more or less authentic information. The thousands of these animals whose "shells" have been made into ornamental baskets and sold throughout the country, make it one of the best-known of all Texas mammals, even in localities which it does not inhabit.

Students of Baylor University have been of much assistance to me in working out the range of this animal. Many of these young men are fond of hunting and they frequently run across specimens of armadillos on their night expeditions after raccoons, opossums and bob-cats.[1] Several of my informants state that while armadillos are now by no means uncommon in their localities, the animals were unknown until quite recent years to their fathers and other relatives who were also

[1] Several have reported finding specimens in poultry houses. I am convinced that the animals get into such places through accident. On their midnight marauding expeditions after insects, their short-sightedness probably is responsible for getting them into quarters where their visits make them objects of suspicion.

hunters. Vernon Bailey, in his report on Texas mammals, refers to the general belief that this animal is spreading eastward and northward but does not commit himself personally, merely making the statement that the question is not entirely settled by the data in hand.

The Texas range of the armadillo, as outlined by the Biological Survey (1905), starts in a general way with Calhoun and Victoria counties (coast prairie), extending northwestward to the northern boundary of Eastland (central Texas: Palo Pinto country); thence a trifle southwestward to and including the southern part of Martin County (plains); thence southeastward *east* of the foot of the plains, forming the eastern edge of a finger-shaped tract which has its rounded tip in the western half of Sutton, northwestern Edwards, and northeastern Val Verde (Edwards Plateau) counties; thence again northwestward through Crockett, Upton, Ector, Winkler and Loving counties. In the last county, it goes to a point and then widens out, forming a long irregular tract extending southeastwardly, taking in parts of the last mentioned tier of counties, all of Crane and parts of Terrell and Pecos, to the Rio Grande. Armadillos were not at this time known to inhabit the finger-shaped tract but were supposed to be pretty well dispersed over the balance of the country included in the range as above outlined. Outlying counties from which authentic data had already been recorded were Colorado, Waller and Houston, the last being at least 110 miles to the northeast of the eastern line of the main shaded area on the map. The range as outlined on this map was fairly accurate for the time and the government naturalists who worked it out did not state positively that the species held to hard and fast lines of dispersal or that it did not occur in many of the bordering counties the area of which was left unshaded. In the large collection of Texas books in Baylor University library are several volumes relating to hunting in Texas in early times. I have carefully read these but fail to find mention of armadillos in any part of the state except the extreme southern portion. As other quadrupeds of as little importance (and of less striking appearance) were mentioned in these works, had the animal been at all well known, much would have been made of it and more or less wonderful tales related of its habits and peculiarities. In referring to many old works, I find the armadillo spoken of as a "Mexican animal which extends over the northern boundary of that country into Texas."

Lower Rio Grande Valley. Until about the early seventies of the last century, the Lower Rio Grande Valley was the principal home of the armadillo in Texas. It ranged in the coast prairie region north at least

to Matagorda County and was abundant in Refugio, Live Oak and San Patricio counties, so I was told by Rev. A. H. Barber, who had farmed and ranched in that section for many years. I have also been informed that armadillos were not very common near the northeastern border of this section until about 1890 but that a few years later there seemed to be an appreciable increase in their numbers.

Central southern Texas (Bexar and adjoining counties). Edward Drinker Cope in the list of Texas mammals in his paper "On the Zoological Position of Texas" (Bulletin United States National Museum, No. 17, 1880) says "this species I did not see, but I am told by Mr. Marnock of Helotes (Bexar County), that it extends east as far as the Nueces River, and has been killed near Frio City, in latitude 29° north." That this animal is becoming more abundant in many localities is borne out by an excerpt from a letter to the Biological Survey from Mr. H. P. Attwater, formerly of San Antonio, in which he says "During the past few years when armadillos have become so common in the southwest and south-central Texas. . . . ." On my first visit to San Antonio many years ago (1896), I was told that the animal was by no means abundant in Bexar County, and that the majority of the specimens used in the making of baskets were killed in Cameron and Hidalgo counties. It was therefore with a great deal of pride that I bore home a rather dilapidated stuffed specimen purchased from the keeper of the old San Pedro Springs zoo.

Austin and the granite country. From all the information that I have been able to glean, the armadillo was not common in this region before 1890 and it was many years afterward before it became widely distributed. Dr. Frederic W. Simonds, in his "Geography of Texas" (first edition, 1904), says that this species "enters Texas from Mexico and is occasionally found to the north and east as far as Austin." Had the armadillo been a native of Travis County as far back as the early eighties, Alexander Sweet, Texas' only real humorist, and editor of "Texas Siftings," would not have failed to give the odd-appearing animal a write-up—he memorialized the coyote, rattlesnake, horned toad, red ant, tarantula, scorpion, centipede, and other animate creatures characteristic of the south-central portion of the state. In "The Mammals of McLennan County, Texas,"[2] I make the statement that old settlers of Burnet County claim that as late as 1890 the animal was unknown there. The men who furnished this information were intelli-

[2] Baylor University Bulletin, 1924, vol. 27, part 1, pp. 3–20.

gent ranchmen and farmers who lived much of their lives in the open and were the class most likely to come in contact with wild animals. Between Burnet and Clear Creek, and between the former place and Mormon Mills, armadillos are usually found in the creek bottoms and along the edges of fissured hills covered with growths of shinnery.

Plains and Panhandle regions. Any person who is familiar with the configuration of that portion of western Texas usually referred to as the "foot of the plains" can very readily understand how it was possible for the armadillo to extend its range by following the eastern edge of natural barriers from the granite and Concho countries along the edge of the Callahan divide and northward into Armstrong County, in the Panhandle proper. My northern-most record is the vicinity of Claude, where armadillos were reported to me in 1910 by Mr. C. M. Lutrell, a ranchman. Several specimens were killed, so Mr. Lutrell said; and he was sure that none had been seen in that section prior to 1905. H. H. Gooch told me that he had heard of an armadillo in Kent County and Scott Cotton reported one from Garza County about 1908. The two last mentioned counties are on the plains between the northern-most counties indicated on the Biological Survey map and the Panhandle.

East-central Texas. The first armadillo recorded from Waco was in 1903. I had then resided in McLennan County for fourteen years. They have since been captured at Chalk Bluff, China Spring, Erath, Crawford, South Bosque and Hallsburg. In east-central Texas, they have also been reported from Hamilton, Bosque, Bell, Coryell, Falls, Limestone, Freestone, Milam and Navarro counties.

Eastern Texas. While at Athens, near the eastern edge of the timber belt, I saw a mutilated specimen of an armadillo hanging in front of a store and I was informed by the storekeeper that two others had been killed in that part of Henderson County. Later, I was told by Mr. La Rue, a former Baylor student, living in the same county, that two others had been killed by hunting parties between Athens and Chandler. I inquired about this species in Smith, Van Zandt, Gregg, and adjoining counties. Several of the natives knew the animal but only general and not specific localities were indicated by them. John Minton, Baylor University law graduate and enthusiastic hunter, informs me that a specimen was captured in the summer of 1924 at a point about twelve miles south of Hemphill, in Sabine County. Sabine is one of the extreme eastern counties and borders on the State of Louisiana. Minton has hunted and captured armadillos in the neighborhood of Waco and I consider his record perfectly reliable.

Louisiana. For several years past, there have been reports of queer-looking animals having been seen or killed in northwestern Louisiana. One negro in DeSoto Parish described some peculiar creature as a "dry-lan' varmint, wid er turpin (terrapin) shell." I was so full of negro folk-lore at the time that I did not suspect that the presumably mythical animal might be an armadillo. Last summer, however, I found my friend, Mr. L. S. Frierson, Jr., of Gayle, Louisiana, in possession of the tail of a specimen which had been killed two miles north of Westdale, Red River Parish. The specimen was in the flesh when brought to Mr. Frierson, but the body was so badly decomposed that he was unable to save anything but the tail. This he preserved in formalin and it is now in his collection.

The principal river systems of Texas from west to east are the Grande, Nueces, Colorado, Brazos, Trinity, Neches and Sabine. In order for the armadillo to extend its range it was first necessary for it to cross the Rio Grande at low water. The high mountainous region west of the Pecos River seems to have formed somewhat of a barrier, so the trend of migration was northeastward rather than northward. In the seventies, the animals had already worked their way across the Nueces and a short time later were in the San Antonio River valley. By 1890, they had reached the Colorado and by 1895, they probably had penetrated to the Brazos valley. At the present time they are found in the drainage areas of the Trinity and Neches rivers, and from the above indicated data have at Hemphill almost crossed the Sabine, and a little higher up have already crossed that stream into the alluvial bottoms between the Sabine and Red rivers. How much further the animal will spread is problematical. In eastern Texas it seems to be occupying the territory formerly inhabited by the peccary and the ocelot. Its ability to suit itself to various physical conditions is one of the most remarkable things in connection with its range extension. It seems to be equally at home in alluvial creek bottoms, the edges of swamp tracts, rock-walled gulches, limestone hills, chapparal prairie and sandy islands.

Baylor University, Waco, Texas.

THE BUFFALO IN NORTHEASTERN CALIFORNIA

By C. Hart Merriam

Four years ago I published a note on Hasting's record of the buffalo in the "*Eastern Section*" of California in 1843, explaining that in those days California extended far enough east to include not only Great Salt Lake, Utah, but also Green River Basin, Wyoming, both of which localities were well known to be within the normal range of the buffalo.[1]

The purpose of that note was to show that prior to 1850 the term "Eastern California" usually meant *eastern Utah* or *western Wyoming*, and that at the date of my note (1922) there was no definite record for any locality west of eastern Oregon—Allen's Sierra Nevada memorandum being without locality, as hereinafter shown.

The following year (1923) Vernon Bailey recorded buffalo skulls from several places in eastern Oregon, including Malheur Lake and Valley, and called attention to the previously overlooked record of the noted trapper and explorer Peter Skene Ogden, who discovered Harney Lake and found buffalo heads there in 1826, just one hundred years ago.[2]

The late Dr. J. A. Allen, writing fifty years ago, said that it was then "probably not yet half a century since it [the buffalo] ranged westward to the Blue Mountains of Oregon and the Sierra Nevada Mountains of California."[3] The Oregon record was from Prof. O. C. Marsh, who in 1873 found remains on Willow Creek in the eastern foothills of the Blue Mountains. The Sierra record was obtained by Doctor Allen in Salt Lake Valley from a hunter named E. D. Mecham, who in 1871 told him that he had seen weathered buffalo skulls as far west as the Sierra Nevada. This was confirmed by other persons whom Doctor Allen met in Salt Lake Valley. But unfortunately no information whatever was given as to the locality or localities to which these observations relate, and subsequent authors have overlooked them or not regarded them as sufficiently authentic.

In my early work among the Indians of California it never occurred to me to inquire about the buffalo, but more recent field work has brought to light the important fact that the Pit River tribes (*Achomawan* stock) and the Northern Piute (*Shoshonean* stock) knew the animal well and had much to say of its former range in their country. From them I have secured absolutely trustworthy records for many of the open

[1] Journ. Mammalogy, vol. 3, no. 1, pp. 54–55, Feb., 1922.
[2] Journ. Mammalogy, vol. 4, no. 4, p. 254, Nov., 1923.
[3] The American Bisons Living and Extinct, 118–119, 1876.

semi-desert valleys of Modoc and Lassen counties, namely: Surprise Valley, Alturas Valley, Hot Springs Valley, Madeline Plains, Horse Lake Valley, Eagle Lake Valley, the valley of Pine Creek on the west side of Eagle Lake, and Honey Lake Valley.

To complete the record it should be added that several of the Pit River tribes—the *At-wum'-we* of Big Valley, the *Ham-mah'-we* of South Fork Pit River, and the *Ap-woo'-ro-kāe* of Dixie and Eagle Lake Valleys—as well as the Northern Piute of Surprise Valley, tell me that the buffaloes were not permanent residents of their country but that small herds came in from time to time, coming from the north—*not* the east—and ranging southerly and southwesterly over the valleys mentioned. The older Indians of several tribes say that their fathers hunted and killed buffaloes in their own territory, and the *Ap-woo'-ro-kāe* believe that a small detached band lived permanently in Pine Creek Valley.

The Northern Piute name for buffalo, as well known, is *Goo'-choo* or *Goot'-tsoo*. The Pit River tribes had no independent name of their own but adopted the Piute name, thus indicating that they were well aware of the fact that the animal came from Piute country.[4]

Evidence of another kind that the buffalo was well known in the country along the boundary between northeastern California and northwestern Nevada is afforded by certain geographic names on early and present-day maps. Thus "*Buffalo Spring*," on the west side of Smoke Creek Desert, twenty miles north of Pyramid Lake, appears on maps 3 and 4 (1855) of the region in northern Nevada between the Humboldt Mountains and Mud Lake, published in the Pacific Railroad Reports, and occurs also on recent maps.

"*Buffalo Salt Works*" on the western border of Mud Flat (now known as Smoke Creek Desert) is engraved on the Wheeler Survey map of the California-Nevada boundary region north of Lake Tahoe (1876–1877); and "*Buffalo Canon*" a little farther west (longitude 119° 55″) and only a few miles east of the California line is located on the same map.

"*Buffalo Creek*," entering Smoke Creek Desert from the west, twenty miles north of Pyramid Lake, is shown on various maps, including the Land Office Maps of Nevada of 1886 and 1914.

"*Buffalo Meadows*," on Buffalo Creek twenty miles above its mouth on the west side of Smoke Creek Desert, is shown on the same maps.

All of the above mentioned localities lie between Smoke Creek Desert

[4] The forms of the name as given me at different times by the eastern Pit River tribes are: *Goo'-choo* by the At-wum'-we and Ham-mah'-we; *Goo'-cho* by the Ap-woo'-ro-kāe. The Klamath name is *Yuho'*.

in northwestern Nevada and the adjacent northeastern boundary of California.

Allen's large map of the distribution of the buffalo (in his Memoir on the American Bisons, 1876) shows its supposed range west of Great Salt Lake by means of a broad colored band which passes *completely around the west side of Salt Lake* and spreads thence westerly over the eastern half of northern Nevada. But his text fails to justify any part of this distribution, his only records for the region west of the Wasatch Mountains being confined to the extreme eastern border of Salt Lake Basin. There is no record at all for any part of western Utah or for the State of Nevada.

Hornaday's map of 1889 is based on Allen's and naturally perpetuates the same error.

For the benefit of persons unfamiliar with this region it may be worth while to call attention to the circumstance that Allen's colored band on the west side of the great lake covers the deadly expanse of salt and clay that forms the flat bed of this terrible lifeless desert, at one time a part of ancient Lake Bonneville.

There is ample evidence that the animals did not push westward around the south end of Salt Lake. The most southerly point in Utah from which there is any record is Utah Lake, from which bones were recorded by Henry W. Henshaw (Allen, 119), and where buffaloes were seen in August, 1826, by the famous explorer and fur hunter Jedediah Smith, the first man to accomplish the overland journey from the Rocky Mountains to California. They could not have gone many miles farther west before encountering the impassable obstacle of the Great Salt Desert—now (1925) for the first time traversed by a road, the Wendover Cutoff.

The natural and only practicable route was around the *north* end of Salt Lake, on or near the Utah-Idaho boundary, which appears to have been the southern limit of their passage westerly and northwesterly across Idaho on the way to Oregon.

This northern route is substantiated by the journal of Zenas Leonard, a member of the Joseph Walker expedition of beaver trappers sent to California by Bonneville in 1833. Leaving the Green River country on July 24, the party reached the north end of Salt Lake on August 4.[5] Here, Leonard states, "We killed our last buffalo on the West side of the

[5] Date given by Leonard as September 4 on p. 149, but on p. 177 corrected to August 4. Narrative of the Adventures of Zenas Leonard written by himself, Clearfield, Pennsylvania, 1839 (p. 149 of Wagner's reprint, 1904).

Salt Lake," adding, "We still continued along the margin of the Lake, with the intention of leaving it when we got to the extreme west side of it" —which they did on the 13th. Whether the exact spot where the "last buffalo" was killed was near the locality now known as Monument (where the shore dips to the southwest) or at one of the two other places between Monument and Kelton where the shore turns southward, may never be known and is in fact of little consequence.

This much of a digression has seemed necessary in order to establish several important facts, namely: (1) that the buffalo did not push westerly around the *south* end of Great Salt Lake; (2) that there is no record of its occurrence on the west side of Salt Lake, or in the valley of Humboldt River, or anywhere in the vast desert region between Great Salt Lake and California; and (3) that it entered California—and probably also a narrow strip along the extreme western border of northern Nevada—*not* from the east but from the north, coming south from Oregon.

With these facts in mind, the extension of the buffalo into the open valleys of northeastern California, carrying its range at least 250 miles southwest of Peter Ogden's record, marks another step in the knowledge of the distribution of this great animal—an animal that stands alone, whether viewed from the standpoint of the food, clothing, and shelter it afforded the original inhabitants, or from its influence in developing the traits of courage, alertness and skill for which our plains tribes were famous.

Washington, D. C.

PROMETHEOMYS, A REMARKABLE RODENT FROM THE CAUCASUS

By S. I. Ognev

[*Plate 19*]

The late Russian zoologist, K. A. Satunin, in his well known article "Ueber ein neues Nager-Genus (Prometheomys) aus dem Kaukasus," Zoologischer Anzeiger, vol. 24, no. 653, 1901, pp. 572–575, is the only one who has described this most remarkable rodent of the Palearctic fauna. At the time this author wrote his interesting work he had but two specimens of this animal. Later the director of the Caucasus Museum, Mr. A. N. Kaznakov, made a special trip to the Gudaur, the only known point inhabited by *Prometheomys*, where he obtained a few specimens and dug out several burrows. He published a paper in which he gave a sketch of the whole life of the animal (Einige Beobachtungen über die Lebensweise von Spalax microphthalmus und Prometheomys schaposchnikowi, Mitteilungen des Kaukasischen Museums, vol. 4, 1909, pp. 147–149).

In 1923 I was with a zoological expedition in the north Caucasus and visited the Gudaur summit especially to obtain specimens of *Prometheomys*. In my paper "Rodentia of the North Caucasus" (1924, pp. 40–44), I gave a brief description of the principal results of my explorations. I will here give a more complete review on this interesting subject. For my investigations, I have had nine specimens of *Prometheomys*, seven from my own collection and two from the collection of the Zoological Museum of Moscow University.

The skull of *Prometheomys* has the following peculiarities: (1) The nasal part is elongated with the incisors markedly protruding, a characteristic of the typically fossorial rodents; (2) the nasal bones are very much broader anteriorly than posteriorly; (3) the interorbital constriction is very decided; (4) the sagittal crest in the old specimens is exceedingly well developed; (5) the interparietal is very small, and is composed of two parts which are united only in the adult specimens, but with the suture between them noticeable even in the old animals; (6) the narrowness of the transverse diameter of the parietal bones equal to one-half the greatest width of the skull; (7) the audital bullae very small and flat, their length approximately equal to the upper molar tooth-row; (8) the bony palate in its structure reminds one of that of the genus *Evotomys*. The sloping portion of the median ridge is invisible.

The mesopterygoid fossa is very broad in front (near the anterior ridge of the praesphenoid); hamular processes, which border laterally the basisphenoid, are formed by two thin parallel plates.

The skull of the young *Prometheomys* is very different from that of the adult in the occipital region dropping backwards its nasal portion, which is shorter and slightly drawn down anteriorly. Besides this, the

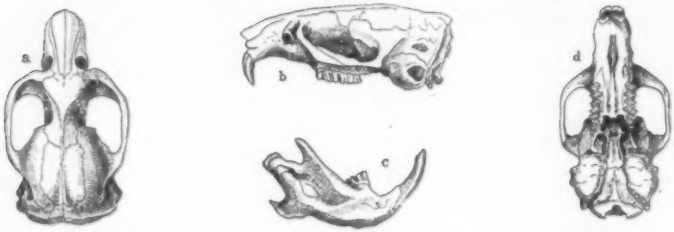


FIG. 1. SKULLS OF PROMETHEOMYS SCHAPOSCHNIKOWI, ADULT MALE

a, dorsal view; *b*, lateral view; *c*, lateral view of mandible; *d*, ventral view. All natural size.

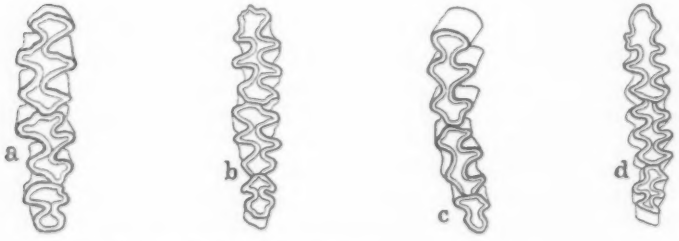


FIG. 2. ENAMEL PATTERNS OF PROMETHEOMYS SCHAPOSCHNIKOWI AND ELLOBIUS TALPINUS

a, *Prometheomys*, upper tooth row; *b*, *Prometheomys*, lower tooth row; *c*, *Ellobius*, upper tooth row; *d*, *Ellobius*, lower tooth row. Enlarged four diameters.

interorbital constriction is wider, and the parietal broad (its greatest transverse breadth in the young specimens 8 mm., while the greatest width of the cranium is 12.5 mm.). The interparietal is strongly contracted transversely and is composed of two separate parts. The audital bullae, compared with the occipital region of the skull, are more swollen than in those of the adult. The zygomatic arches are much

narrower and their greatest width is not in the median part, as in the old and adult specimens, but in the posterior portion.

The structure of the teeth is sufficiently constant. In the young specimens the enamel loops are narrower and sharper; on the upper loops small swellings are visible in their middle parts, also a narrowness in their basal parts and at the tips. In the adult and old *Prometheomys*

TABLE 1

Measurements of Prometheomys schaposchnikowi in collection of S. I. Ognev

	KOBY, RUSSIA			GUDAUR, RUSSIA		
	No. 4, Male. September 6, 1923	No. 3, Male. September 6, 1923	No. 5, Female. September 7, 1923	No. 510, Male. August 15, 1923	No. 1, Female. September 5, 1923	No. 2, Male. September 5, 1923
	mm.	mm.	mm.	mm.	mm.	mm.
Total length of skull	30.8	31.1	29.5	31.7	32.9	32.7
Basal length of skull	26.8	28.9	25.3	28.8	29.8	29.2
Condylobasal length	30.1	31.6	28.6	32.1	33.1	32.6
Greatest breadth of skull	14.2	14.8	14.0	14.9	14.8	14.7
Interorbital breadth	4.2	3.8	4.2	3.7	3.9	3.9
Zygomatic breadth	17.6	18.1	17.3	19.3	18.9	18.9
Length of bullae	8.2	8.5	7.5	8.1	7.9	7.8
Breadth of bullae	5.4	6.1	5.7	6.1	5.8	5.6
Length of nasals	9.3	9.8	8.8	9.7	10.2	10.2
Breadth of nasals in front	4.2	4.3	3.9	3.8	4.3	4.8
Length of parietal at suture	5.3	6.0	6.0	7.6	7.9	8.0
Length of rostrum	8.3	8.1	7.8	8.3	8.6	9.1
Greatest depth of skull	12.3	12.5	12.2	12.2	12.0	12.1
Length of molar row	7.3	7.6	7.4	7.9	8.0	7.6
Length of body	125.0	126.0	117.0	141.0	141.0	147.0
Length of tail	39.0	42.8	38.3	45.0	42.5	43.0
Length of hind foot	22.6	21.9	22.2	23.0	21.7	22.0
Length of ear	14.0	13.0	13.2	15.7	12.8	13.2

the loops are wider and blunter. The teeth of such old specimens, frankly speaking, are badly drawn in the Satunin's paper (Zoologischer Anzeiger, vol. 24, 1901, pp. 573–574, figs. 1–4). Prof. A. Nehring has already indicated the incorrectness of these drawings.

The general tint of the fur on the back of an adult specimen is a dull gray brown with a cinnamon mixture; on the sides it is more of a wood-brown, and comparatively lighter plumbeous-gray on the belly, where

there is a conspicuous light cinnamon tint. The color of each separate back hair, the length of which in the summer specimens is about 15 mm., is as follows; at the base for a considerable length it is between slate-gray and slate, passing into blackish slate (Ridgway, 1912, pl. LIII). The tips of most of the hairs are a grayish cinnamon color; among such colored hairs are many that have completely black apical parts. The basal halves of the belly hairs are a light neutral gray; the tips are dull-whitish with a ferrugineous shade. The tail is unicolored brownish-gray. In some specimens the tail tips are white (for example the *Prometheomys* from the environs of Koby station), and near the white tips can be seen an admixture of pure black hairs. The basal half of the tail is markedly swollen and big, a very characteristic peculiarity.

The vibrissae are comparatively short, thin and composed of a mixture of blackish-gray and whitish hairs. The feet are covered with dull brownish gray fur; the claws are yellowish white. In the adult specimens the claws of the fore feet are unusually long, especially those of the middle toes. The soles, particularly of the hind feet, are covered in their posterior parts by short hairs. The shape and disposition of the sole pads are similar to the same in the genus *Ellobius*. It is possible that this peculiarity is developed from the similarity of their biological conditions of a fossorial manner of life, which is characteristic of both of these animals. The hind sole of *Prometheomys* has six pads, of which the exterior hindmost is the smallest of all. The pads are disposed successively in pairs each fore sole having five pads of which the back pair of pads are the largest, especially the stretched exterior one.

Young specimens are of a duller brownish gray color, the belly somewhat lighter than the back, and the tint intermediate between hair-brown and benzo-brown.

In its systematic relations *Prometheomys* scarcely differs from the remaining genera of Microtinae. In its dental peculiarities this animal is near *Ellobius*, especially *E. talpinus*, but the skull is very different. The skull structure, principally the form of the parietals, is similar to the same in the genus *Fiber*, but the rest of the characteristics do not resemble it.

This remarkable endemic genus of Rodentia has an exclusively very narrow geographical distribution; it lives only on the Cross summit, near Gudaur. On the southern declivity of the mountain summit it extends its range half way to the village Mleti, and it is clear that it lives in the Kajshaur Valley and near Lake Kell, for on the summit (of the north part of the mountains) *Prometheomys* formerly was dis-

covered by myself in very great numbers near the station Koby, and according to the information received, it is very rarely seen near the station of Kazbeck.

On the very first day of our arrival at Koby we heard from the natives about this peculiar mouse, the Georgian name for which is "tagwy." This mouse, as we were told, digs underground passages and spoils the subalpine meadows. In our first excursion we saw these interesting passages which were visible near the little chapel not far from Koby, and further in the mountains, especially in the glades of small birch-woods, we saw a very great quantity of them. One can say that here the whole earth is excavated by this remarkable animal. In the region of the *Rhododendron* the burrows are rarer, although such passages were found by us in the alpine zone, above the zone of the *Rhododendron*. On the way from Koby station to the summit the passages are numerous for about four versts from the Cross. Examining one of the systems of these burrows, I was surprised to see an old *Prometheomys* peering out of a burrow, half of its body being visible, with the remainder in its underground hole.

All our efforts to catch these animals were in vain. Near the Cross we saw a great quantity of burrows and passages. Here the whole earth is excavated by their burrows. We dug up approximately fifteen subterranean structures of this rodent. It was difficult work. Like the mole, *Prometheomys* makes a shallow burrow with numerous passages which are arranged in rows, or in a circular figure, but the spaces between them are shorter compared with those of *Talpa*. The arrangement of the passages is similar to that of a colony of the vole (for example of *Chilotus socialis* or *Microtus arvalis*), but the passages are much larger, and very much like those of the mole.

Finally we had the fortune of finding a whole system of passages, in the center of which was the nest. It was situated in a space, the diameter of which was nearly 22 cm., at a depth of 40 cm. underground. The nest was formed of soft and delicate blades of grass. Its general aspect was like that of the vole's nest, but it was much larger. From the space in which the nest was placed could be seen five burrows, but in their arrangement we could not detect the regular radiality described by Kaznakov (l. c., 1909, p. 148).

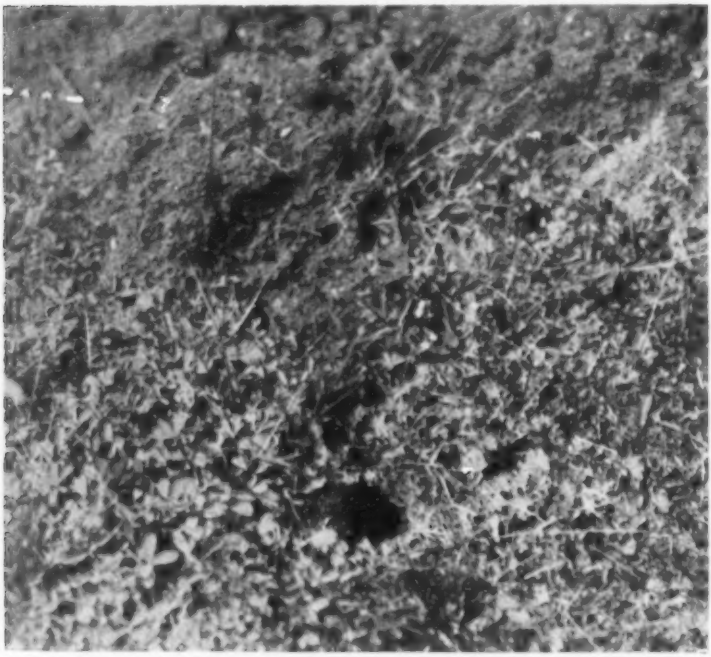
The holes, set deeply in the center of all the subterranean structure, radiate from the nest, gradually rising to the surface. The openings of the burrows are not only disposed at the periphery of the nest-room, but in the center of the structure. The exterior opening of the burrow is 5.6

cm. in diameter, narrower than the subterranean passages, which are not uniform in width in all the parts of the erection, their breadth varying from 7 to 10 cm. When one is digging out the holes it is possible to see that from the principal burrow additional ones lead to an accessory form. This is short and made for throwing back the earth from the general gallery, as by *Spalax*. The passages are of various dimensions. Generally they are a little shorter than those of the mole; those opening into the center of the nest are often the largest.

The animal moves very slowly and rises to the surface of the ground only when all of its structure is destroyed. The natives say that *Prometheomys*, when it travels on the surface, is very easy to catch. This animal goes out more often in bright sunny weather. Mr. L. Beme, who obtained several, made an interesting observation: the animals begin to rebuild their burrows, which had been destroyed the day before, at night and work to about four or five o'clock in the afternoon. At that time it is easy to detect where the animal is by the earth it throws out and it can then be dug out with a shovel. This animal is active also during the winter, when it goes out on the snow. *Prometheomys* feeds on the grass of the alpine meadows, digging up the earth, and so destroys the roots of the grass and spoils the meadows. Mr. Kaznakov writes: "A person who lived in the Gudaur village for thirty years told me that formerly the peasants gathered from 400 to 500 ricks, whereas now they collect only from 150 to 200 ricks, although the recent ricks are far smaller than before."

Moscow, Russia.

SPECIMEN OF PROMETHEOMYS SCHAPOSCHNIKOWI IN THE FLESH
About two-thirds natural size



BURROW AND MOUNDS OF PROMETHEOMYS NEAR GUDAUR, RUSSIA

UNIV. OF MICH.

CRITICAL EXAMINATION OF THE MEADOW MICE OF LOWER CALIFORNIA

By Joseph Grinnell

The only species in the genus *Microtus* known from Lower California is *californicus*. This representative was first recorded, on the basis of specimens taken in the Sierra San Pedro Martir by E. C. Thurber, by J. A. Allen (1893, p. 184), who referred it "with much hesitation" to *Arvicola edax* Baird. Then D. G. Elliot (1903*a*, p. 161), on the basis of Edmund Heller's collections, named *Microtus californicus huperuthrus*, giving the type locality as "San Quentin, Lower California." The same author (1903*b*, p. 218) changed the spelling of this subspecific name to "*hyperythrus*," intimating that it was previously "misprinted." Later (1907, p. 292) he stated that the type locality of "*hyperythrus*" had been given as "San Quentin" "by some quite inexplicable inadvertence;" the specimen he now considered as type came from La Grulla. In his revision of the *Microtus californicus* group of meadow mice, Remington Kellogg (1918, p. 34) adopted Elliot's name for the "Lower California Meadow Mouse," as originally spelled—*huperuthrus;* but he accepted the "corrected" type locality and based his very full description exclusively upon seven specimens (including the "type") from La Grulla, borrowed from the Field Museum.

The above historical recital would be needless were it not that the material now at hand from Lower California shows that there are *two* definable subspecies of *Microtus californicus*, the range of one of them lying in the low coastal district which contains the locality San Quintin [the correct spelling], and that of the other embracing the San Pedro Martir plateau upon which is the locality called La Grulla. It is in order to give a new name to one of them; but to which one?

A principle may here be set forth, to which exception will unlikely be made: No author has any more right to replace or emend a name proposed by him, once it is published, than any other author has right to do so; laws of priority apply just as strictly to him subsequently to publication, with reference to his names, as to anyone else. Elliot's first spelling of the name of his new Lower California meadow mouse should be adhered to, since it was not a typographical error in the usual proper sense; he simply later changed his mind as to the spelling, on etymological grounds. This is shown by the fact that he did the same thing in a number of other exactly similar cases.

Now, I believe the above principle should be extended to designation

of type localities and types. In his original description of *Microtus californicus huperuthrus*, Elliot not only unequivocally states San Quintin to be its type locality, but his description (and also the subspecific name chosen) applies to the race existing in that locality rather than to the one at La Grulla. The phrases "upper parts dark tawny, or tawny ochraceous," and "reddish," apply definitely to the San Quintin examples and not to the La Grulla ones. The latter, as I shall set forth presently, are distinctly gray toned. Furthermore, that Elliot, when he proposed the name *huperuthrus*, had chiefly or altogether in mind skins from San Quintin is shown by the exclusive use of this place-name in his statement of geographical distribution. Only farther along, in his general remarks, does the place-name La Grulla come in, as follows (1903*a*, p. 162): "It was not found on the coast north of San Quintin, and ranges in the mountains east of that place to La Grulla and Agua de las Fresas, about 8,000 feet altitude."

In this connection I have before me, on loan from the Field Museum of Natural History, through the courtesy of Director D. C. Davies of that institution, the entire series of *Microtus* collected by Heller in Lower California. These 31 specimens do not check up exactly, as to numbers of specimens from each of the localities, with Elliot's (1903*b*, p. 218) first itemized record of them; but they do with his later catalog (1907, p. 292). None of them now has any original label. Each, including the present "type" (with red tag, no. 10740), bears only *copied* data. Why the present "type" was selected eventually as such, becomes apparent when we find that the only measurements given with the original description (Elliot, 1903*a*, pp. 161–162) apply as regards external dimensions to just this one skin out of the whole series. It shows the greatest total length in the series, save one from San Quintin (a reddish skin). This latter, however, has a somewhat broken skull; but whether this circumstance is significant it is impossible for me to say, since I am unable to get from either of the skulls, measurements which concord with the single set of skull measurements given by Elliot. The point that has finally appealed to me here, is that the fact of the body measurements having been given for a La Grulla skin does not out-weigh the fact that San Quintin was first designated unequivocally as *the* type locality and that the name chosen and the color-characters given are those of the San Quintin race. It is upon this basis of fact and inference that I now decide that it is the gray-toned San Pedro Martir subspecies that requires naming.

As to which one from among the twelve topotype specimens of

huperuthrus is the true type may not now be ascertainable. It is possible that scrutiny of old notes or labels in the Field Museum might determine this. In default of any such definite determination of typeship, then it would be in order for someone arbitrarily to pick out a type. Certainly, Elliot's so-called "type" has no more standing than any of his other five or six examples from La Grulla.

Any suggestion of impropriety in the above discussion, it will of course be understood, does *not* apply to anyone now connected with the Field Museum of Natural History where, in its Department of Zoology under the able curatorship of Dr. Wilfred H. Osgood, the most modern and accurate methods of curatorial and systematic procedure have been adopted.

[Since writing the preceding paragraphs, I have received from Doctor Osgood the original label, which happily proves to have been preserved in the Field Museum, belonging to Elliot's "type." The face of this label bears the field data, in blue ink, in Heller's hand-writing, and also, in black ink, "Type 10740," in the same writing as all of the written inscription on the red type-label now attached to the skin. On the back of the original label appears, in lead pencil of one vintage, "Microtus c. huperuthrus, Elliot;" and in another hand-writing with a different pencil, as shown by the use of a lense, *y* written over each of the original *u's* in the subspecific name, and the word "Type" on a line below. This, to my mind, proves conclusively that the selection of a type specimen was synchronous with Elliot's decision to emend the spelling of his name, and this, as shown above, was long after the publication of the original description of *Microtus californicus huperuthrus*.

This case developed such puzzling angles that I sought advice from Dr. W. H. Osgood and from Gerrit S. Miller, Jr. But these experienced systematists proved to have almost opposite views in certain respects! My own line of reasoning, as herein set forth, departs in some points from either of theirs, so that mine will have to stand alone, and survive or fall in the light of further evidence or more convincing argument toward some other solution.]

Microtus californicus perplexabilis, new subspecies

San Pedro Martir Meadow Mouse

Type locality. La Grulla, 7000 feet altitude, Sierra San Pedro Martir, Lower California. *Type*, no. 35882, Mus. Vert. Zool.; ♂ adult, skin and skull; collected May 13, 1925, by Adrey E. Borell; orig. no. 1642.

Diagnosis. Similar to *Microtus californicus neglectus* Kellogg (1918, p. 31)

[this subspecific name, owing to preoccupation in the genus, replaced by the name *sanctidiegi* Kellogg, 1922, p. 78], but size averaging larger throughout (hind foot in adults 24 to 26 mm., condylobasal length of skull in largest individuals 31.5 to 33.0 mm.); coloration gray-toned rather than reddish; skull, age and sex being considered, with less widely spreading zygomatic arches, dorsal profile as a rule more flattened, auditory bullae slightly smaller, and incisor teeth less incurved (more forward projecting).

Measurements. Rather than a full table, dimensions are given here of but one selected example of each race—selected to secure equivalence as to age so that the figures are really comparable. This age is fairly mature adult, not "overgrown." As to the external dimensions, taken by the field collector, the one dimension of "hind foot" must not be taken as significant, since each of the first two is an extreme for its race and happens to be opposite.

TABLE 1

	CONDYLOBASAL LENGTH	OCCIPITONASAL LENGTH	BASILAR LENGTH OF HENSEL	NASAL LENGTH	ZYGOMATIC WIDTH	INTERORBITAL CONSTRICTION	HEIGHT OF BRAINCASE AT BULLAE	MASTOID WIDTH	UPPER MOLAR SERIES	TOTAL LENGTH	TAIL VERTEBRAE	HIND FOOT	EAR FROM CROWN	WEIGHT (GRAMS)
M.c. perplexabilis, ♂, no. 35882, La Grulla, Lower Calif.	31.5	31.0	27.8	10.0	17.6	3.9	11.5	13.7	7.9	195	57	26	11	66
M.c. huperuthrus, ♂, no. 35874, San Telmo, Lower Calif.	32.4	32.0	28.7	10.4	19.0	4.1	11.4	14.3	7.2	204	57	23	10	82
M.c. sanctidiegi, ♂, no. 7671, Foster, San Diego Co., Calif.	29.3	29.0	26.0	9.1	16.8	3.7	11.3	13.3	7.5	171	55	24	—	—

Remarks. Kellogg's (1918) very detailed descriptions, comparisons, and measurements of "*huperuthrus*", it must be understood, pertain to the subspecies here named *perplexabilis*. For Kellogg had before him only the seven La Grulla specimens; he did not see Elliot's series of San Quintin Meadow Mice which, according to my above interpretation, formed the real basis of *Microtus californicus huperuthrus* Elliot. It is in order here to present some further facts in regard to the latter race.

In the *Microtus californicus* group of meadow mice, *huperuthrus* is notably reddish in color; it averages redder even than does *sanctidiegi* or *mariposae*. *Huperuthrus* and *perplexabilis*, the former of Austral habitat, the latter of Boreal habitat, are both of maximum size in the *californicus* group, decidedly larger, especially as to skull, than the next nearest neighboring race to the north, *sanc-*

tidiegi, and very much larger than the northernmost races in the group, *constrictus* and *eximius*. Here is a suggestive reversal of the "rule" that in geographically variable mammals in North America size varies from large at the north to small at the south.

M. c. huperuthrus is nearer *sanctidiegi* than *perplexabilis* not only in color but also in certain features of the skull. On the comparison, in series, of females and of middle-aged males (not "overgrown" males), *huperuthrus* is seen to have more widely spreading zygomatic arches, wider braincase, less flat-topped cranium, and more incurved incisors, than *perplexabilis;* and these are some of the features which distinguish the former from *sanctidiegi* also. Indeed, as already intimated, the chief differences between the latter two races lie in absolute size and these, as such things are customarily appraised in the genus *Microtus*, are quite appreciable.

The color difference, reddish in *huperuthrus* and grayish in *perplexabilis*, extends to all ages; in half or third grown young, while there is less reddish than in adults in the former, the marked relative grayness of the latter is easily perceptible in the mass. It should be stated, of course, that in each of the characters here mentioned ordinary individual variation brings overlapping. The Lower California forms here distinguished by name are both subspecies of the species *californicus* in the true conception of the term subspecies.

MATERIAL

Microtus californicus perplexabilis: La Grulla, 7000 ft., 12 (MVZ) + 7 (Field Mus.);[1] Vallecitos, 8500 feet, 3 (MVZ) + 3 (Field Mus.); Concepcion, 6000 feet, 4; Agua de las Fresas, 6000 feet, 7 (Field Mus.). All these localities are on the Sierra San Pedro Martir. Total, 36 specimens.

Microtus californicus huperuthrus: San Quintin, 12 (Field Mus.); San Ramon, 11 (MVZ); San Telmo, 11 (MVZ); San Antonio, 2 (Field Mus.); San José, 2500 feet, 1 (MVZ). All these localities are below the 3000-foot contour, toward or near the Pacific coast, and within 50 miles north and northeast of San Quintin. Total, 37 specimens.

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———1903*b*. A list of mammals collected by Edmund Heller, in the San Pedro Martir and Hanson Laguna mountains and the accompanying coast

[1] One of these, no. 10741, is so like *huperuthrus* that I suspect that it was a lowland specimen mis-labeled. This suspicion is strengthened by the fact that Elliot's enumeration of his specimens by locality in 1907 (p. 292) does not agree with his enumeration in 1903 (*b*, p. 218).

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GENERAL NOTES

AN OBSERVATION ON THE HUNTING METHODS OF THE TIMBER WOLF

On June 26, 1925, I was close witness to an incident of unusual interest which occurred at the extreme northern end of the Snowy Range in the Medicine Bow Mountains, at a point about forty miles northwest of Laramie, Wyoming (Section 35, T. 17 N., R. 79 W.). At eleven o'clock in the morning while following timberline (altitude here about 10,700 feet) toward a low divide in the range, I was startled by a rush and a crash sounding from a point about a hundred yards up the slope to my right. In quick succession there followed a number of peculiar, deep-throated sounds such as I could not recall ever having heard before. My first thought was that I had stumbled upon a litter of wolf or coyote whelps tussling about their den. Quickly I took five or six steps forward so as to see around the low timberline trees that at first obscured my view. A single glimpse convinced me that this was far from being a matter of mere animal horseplay. About a hundred yards up the slope was a whirling mass of greyish fur, twisting and rolling with such rapidity that I could not possibly determine what animals constituted the struggling group. From time to time came the same low-pitched sound, a strained monotone which could only come, I was sure, from the throat of a choking animal. It was not pleasant to hear. In its rapid gyrations the fur mass edged toward the brink of an incline five or six feet high. Over this it finally toppled, falling with a crash upon a mat of flat-topped timberline trees below and sinking into it out of sight. By means of the noise of the smashing boughs I followed the course of the combat. The sounds from the choking animal became fewer and more labored, little more than occasional forced wheezes. Suddenly all sounds ceased. There came the sound of a spasmodic shake; a second; a third. Then out from the foliage leaped a timber wolf (*Canis nubilus*) holding in its jaws as a tabby would hold a kitten, the limp body of a dead marmot (probably *Marmota flaviventris*). With indescribable ease the wolf leaped to a rock point and there, beautifully poised, looked calmly down at me. I had no firearm with which to disturb its somewhat exasperating nonchalance. After a few moments it relaxed, and, entirely disregarding me, laid down the marmot in order to take a firmer grip on its neck. Then it started up the slope with long, effortless leaps. When it reached the top, it again turned, still holding the marmot in its jaws, to survey me. Minute after minute passed without change; whereupon, in the faint hope that the wolf might drop its victim, I yelled at it

and threw a pebble up the slope in its direction. It then turned and loped over the ridge out of sight. Probably it carried the marmot off to a waiting litter of hungry young. Later I carefully searched the snowfields on the other side of the ridge for tracks, but found no clues to indicate which direction the animal had taken.

Climbing to the scene of the tragedy I tried to reconstruct the main events that had been enacted before I became an onlooker. The ground was scratched and torn, but of blood there was not a trace, a condition which bore out my belief that at its first rush the wolf had seized the marmot by the throat and throughout the prolonged struggle had not relaxed its grip until the neck of the victim was broken. That is the way of dogs with rats, and other animals. I could not detect the exact point from which the wolf had sprung, but the nature of the cover suggested that it had stalked the marmot from above, creeping along between the rocks and the mats of vegetation. So it had surprised the marmot but a few yards from the latter's den, along a well-worn runway.

The most interesting circumstance connected with this incident is the fact that the wolf must have stalked, captured, and killed its prey conscious all the time of my approach. I could not escape this conclusion, for from any point on this almost barren ridge my movements for the last half-hour must have been plainly visible. When my attention was arrested by the charge of the wolf, I was heading toward the animals and had been doing so for the last five or ten minutes, plowing across a wide snowfield, against which my moving figure must have been sharply silhouetted. If the wolf had not leaped when it did, I would soon have passed a point just a few yards below it. Had the animal been so engrossed in its hunting as to be oblivious to my approach? Sight, smell, and hearing, it seems to me, must have warned it; but unwilling to forego a prey practically assured, it had concluded the stalking in spite of my presence, though probably forced to leap prematurely by my approach.

The marmot appeared to be a very large one; I estimated its weight at not less than 15 pounds. But even at that I am not a little surprised that it should have been able to put up such a battle against an animal so much bigger than itself. Perhaps the wolf failed at the outset to set its jaws in a fatal grip, and therefore had unusual difficulty in dispatching its victim.

This was the first marmot I saw in two weeks time spent near and above timberline on this range. The next day, however, I saw another. At no time did I find any trace of conies (*Ochotona princeps*). The incident narrated above may explain the scarcity of small mammals in these mountains. One or two eagles could almost always be seen hovering over the country above timberline; I have no doubt that they, too, constitued an important factor in keeping down the rodent population.—F. M. Fryxell, *Augustana College, Rock Island, Illinois.*

THE ABDOMINAL SKIN GLAND OF MARTES

When reading the manuscript of "The Fur-bearing Mammals of California," a treatise in preparation by Messrs. Joseph Grinnell and Joseph Dixon, I first learned that the marten possesses an abdominal skin gland. It is there recorded that Mr. Dixon first noted the presence of this gland in a live female marten which he trapped on Warner Creek, Shasta County, California, on September 21, 1923. The skin gland on the belly of this female measured one-half inch in width and

three inches in length. An adult male marten taken seven days later in the same trap and setting, had a well developed oily abdominal gland which measured one inch in width and three inches in length, the glands being measured by Mr. Dixon on the flesh side of the skin just after the pelts had been removed.

On January 17, 1926, an adult marten (*Martes caurina*) was received in the flesh at the Museum of Vertebrate Zoology, where it was preserved as a skin and complete skeleton, bearing the following data: No. 35372, ♂ adult; 12 miles east of Requa, on Terwer Creek, Del Norte County, California; January 13, 1926. While still in fresh condition this example was turned over to the present writer for the purpose of studying its muscular anatomy. In skinning it, opportunity was had to take the following notes on the abdominal skin gland above referred to, and these notes are here given with the consent of the above-mentioned authors.

A glandular area, 8 mm. wide at its middle and roughly elliptical in outline (being, however, narrower anteriorly than posteriorly), extends from the opening of the penis anteriorly for a distance of 40 mm. On this area the longest hairs are 1.7 mm. in length and most of them are shorter than this. In color, these hairs differ from those surrounding the glandular area only in being slightly more reddish, probably the result of staining by the glandular secretion. The individual hairs occur in bundles of seven or eight, there being, at the widest part of the gland, twenty separate bundles arranged transversely to its long axis. In each of these hair bundles both overhair and underfur are represented, the difference in length and thickness between these two types of hair, however, being less than on most other parts of the body. The raised areas from which the hair bundles project are more pronounced than on other parts of the body and are united into transverse ridges. The surface of the skin has a granular appearance, due to the presence of from three to five scale-like, raised areas that occur on the transverse ridges between each two hair bundles.

When the inside of the skin is examined, the glandular tissue is seen to be lobulated, fully 2 mm. in thickness at its center, and distributed over a wider area than the region of short hair on the exterior would indicate. The area covered on the inner surface of the skin is also roughly elliptical in shape and extends from a point 8 mm. posterior to the opening of the penis to a point 50 mm. anterior to the same; it is 22 mm. wide at its middle. When crushed the substance of the gland produces an oily fluid possessing the characteristic marten odor which is not unlike the odor of the weasel, although less penetrating in character.

Mr. Dixon tells me that martens which he observed, both captive and in the wild, were seen to drag their bellies over logs and limbs. While the utility of the gland is of course not definitely known, Mr. Dixon's observations suggest that the abdominal gland may supply a scent that is smeared on various objects, in passing, possibly as a means of information for other members of the race.

The several papers dealing with the marten, that I have been able to consult, make no mention of an abdominal gland. Examination of dried skins of *Martes americana*, *M. nesophila* and *M. caurina* shows the gland to be present in both sexes of each species. Numerous skins of *Gulo luscus*, both males and females, that were examined also all possessed a well defined glandular area similar to that of the martens. However, my examination of dried skins of *Martes pennanti*, *Mustela vison*, *Mustela longicauda*, *Mustela arizonensis* (also alcoholic specimens

of the last two named species), *Lutra canadensis*, *Spilogale phenax*, *Ictonyx libyca*, and *Mephitis occidentalis* fails to show any evidence of an abdominal gland, although it might, in some, be present in a more rudimentary state than in the marten and hence less readily detected on dried skins. That such could well be the case is indicated by my finding in only three of twenty-six dried skins examined, the glands in *Taxidea taxus* described by Pocock (Proc. Zool. Soc. London, 1925, p. 17) from fresh specimens as follows: "These *abdominal glands* are capacious integumental pouches with a somewhat constricted orifice, each opening towards the middle line at the side of a depression in the skin of the abdomen in which the extremity of the penis, enveloped in its hairy prepuce, lies."

In the Mustelidae, ventral abdominal glands of the same type are, then, known to be present in at least three species of the subgenus *Martes* and one species of the genus *Gulo*; and glands, at least similar in position, occur in *Taxidea taxus*. Careful examination of fresh specimens of other mustelids may also reveal abdominal glands in other forms of this family.—E. RAYMOND HALL, *University of California, Berkeley, California.*

THE PRAIRIE-DOGS (CYNOMYS LUDOVICIANUS) AT WASHINGTON ZOO

On November 4, 1925, I went to the National Zoological Park at Washington to see the prairie-dogs. There was an unusually fine lot of animals in the pen at that time, and so tame that they offered good facilities for observation.

The old ones were busied with carrying in hay, either for bedding or for food, or both. None of the young of the year seemed impelled by this provident instinct.

Apparently they never hibernate, as I have seen them running over the snow in deep winter at Gardiner, Montana, in January, 1914. Hence their need for large stores of food underground.

In eating, they sat up on their hindquarters and held the food in one paw. At first, all seemed right-handed, but later I saw one eating left-handed.

When meeting a friend, they saluted by "kissing," that is, with both snouts near the ground, each rubbed its lips first on one side, than on the other of its friend's muzzle.

The old ones were very busy raising the rims of the craters; not by digging out from below, but by gathering the clay from the surface for five or six feet around and building it up into a narrow wall a foot high, as though preparing for a time of floods or deep snow.

Many of them had a trick of nibbling each other's tail around the root. Sometimes an incorrigible nibbler pursued his victim round and round until the persecuted one turned to fight. It seems to be a morbid—a cage—habit, as one or two had lost their tails in part. I never saw anything of this in a state of nature.

When alarmed, they made first for the mound at the hole. On this, they sat up keenly alert. The jerking of the tail once or twice was used as a mere warning, a signal that all the others saw and heeded. Associated with this, was the ordinary "quek" or bark for which they are named. This was definitely a note of alarm. When they were scattered far from their holes, and one gave a sharp "squit-tuck," all ran for cover. The note "skr-skirr" means fighting or menace. It was frequently heard when they were disputing among themselves. They had in addition a number of squeaks and chatters that were used in conversation or in squabbling.

But the most singular vocal exercise was the *song*. This was uttered by the old ones, both sexes I think, at any time, without obvious motive or visible cause. Suddenly one would rear up and with snout to the zenith, utter a soft "Wee-oo," then drop down again onto all four feet. The action was momentary, and defied all attempts to photograph it. But I made the accompanying sketch, which I believe is correct for all those that I saw that day. It exactly suggested the attitude of a sun-worshipper; and the song might be called his song of praise or joy.—Ernest Thompson Seton, *Greenwich, Connecticut.*

COLLECTING BATS WITH A NET

In August, 1924, while collecting at Bartholomew Springs at an altitude of 3900 feet in the Blue Mountains of southeastern Washington, I noticed bats sipping water as they flew over an open pool at dusk. It would have been next to impossible to shoot them against the dark foliage of the adjacent forest, so I began to devise other means of taking them. I first erected a screen of mosquito netting about ten by twelve feet in dimensions at the lower edge of the pool. I expected them to fly against this screen with the probability of my capturing some of them, but none did. When within a few inches of the netting they swerved off, and either passed over or to one side. I then made a net much like an insect net only larger, and with the aid of a flash light secured a number of specimens. It was necessary to meet them coming head on and at that a good many dodged the swoop of the net.

I spent the early part of September collecting nearby at Godman Springs, altitude 5700 feet, where a number more specimens were taken in the same manner. At that season of the year, open pools, which furnish suitable drinking places for bats, are far between, so the animals must come some distance to drink. It rained quite heavily and turned cooler while the writer was at Godman Springs and no bats were seen for two nights.—Storrs H. Lyman, *Dayton, Washington.*

CATCHING BATS WITH GILL-NETS

The preceding note by Storrs H. Lyman should remind some of the older field naturalists that methods of collecting of common practice to them may be novel or unknown to mammal collectors of less experience. The writer of this note always carries a light folding insect net to use in collecting bats whenever he goes into a region where they may be expected in numbers. Often, also, he has knocked down bats with a handful of switches or brush. An excellent way to collect these animals is with ordinary gill-nets, such as are commonly used by fishermen. These nets are made of different depths and with various sized meshes, but those most convenient for use are six to ten feet deep with a half-inch to one-inch mesh, according to the size of bats one desires to capture. The length may vary to suit the convenience of the collector. A net ten feet square is of satisfactory size. Spread across a space where bats are flying, particularly over a stream or pond or across a ravine, it is almost certain to catch numbers of the animals.—HARTLEY H. T. JACKSON, *U. S. Biological Survey, Washington, D. C.*

RECENT LITERATURE

Ecological Society of America, Committee on Preservation of Natural Conditions. Assembled and Edited by Victor E. Shelford. Editor for mammals, Lee R. Dice. NATURALIST'S GUIDE TO THE AMERICAS. Baltimore: The Williams & Wilkins Company. 8 vo, XV + 761 pp., 1 pl., 16 maps. $10.00. March, 1926.

This encyclopedic guide to the faunal and floral areas of the Americas is one of the outstanding biological publications of recent years. Information is here assembled and compiled by a corps of careful editors from studies and observations made by hundreds of able biologists. The book therefore has the mark of authority. There is a noticeable lack of uniformity in the treatment of the different areas, but this could hardly be otherwise with biologists of varying interests reporting the different areas; and, in reality, it does not seriously detract from the work.

The book consists of six primary divisions, the first being a very brief "Introduction," followed by one on "Uses, values and management of natural areas," and a third on "Original biota of the Americas." The fourth division, the "List of natural areas and regions," constitutes the main and most useful part of the book. The fifth is devoted to a "List of organizations interested in preservation of natural conditions," while the final is the index.

The Ecological Society of America and all concerned in the production of this work are to be congratulated upon bringing to completion such a stupendous undertaking. The book is one which will find constant use, not only among biologists, but among all who are interested in outdoor America.—HARTLEY H. T. JACKSON.

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Buck, Frank H. A man-eating tiger. Parks and Recreation, vol. 9, pp. 366–371. February, 1926. (Account of the capture of a tiger.)

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THOMAS, OLDFIELD. Two new rock-wallabies (*Petrogale*) discovered by Capt. G. W. Wilkins in northern Australia. Ann. and Mag. Nat. Hist., ser. 9, vol. 17, pp. 184–187. January, 1926. (New species: *P. wilkinsi* and *P. longmani*.)

——— On some small mammals from Madagascar. Ann. and Mag. Nat. Hist., ser. 9, vol. 17, pp. 250–252. February, 1926. (New forms: *Ericulus setosus melantho* new subsp.; *Microgale principula* and *M. sorella* new sps.)

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——— A revision of the genera Taphozous and Saccolaimus (Chiroptera) in Australia and New Guinea, including a new species, and a note on two Malayan forms. Rec. Australian Mus., vol. 14, no. 4, pp. 313–341, pls. 47–48. April 9, 1925. (Describes *Saccolaimus mixtus* sp. nov.)

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EIGHTH ANNUAL MEETING OF THE AMERICAN SOCIETY OF MAMMALOGISTS

The eighth annual meeting of the American Society of Mammalogists was held at the American Museum of Natural History in New York City from April 27 to May 1, 1926, with approximately seventy members in attendance.

The first feature of the meeting was a tour, the afternoon of the 27th, under the auspices of the National Association of the Fur Industry. The first place visited by the twenty or more members present was a raw-fur receiving house. The second was a large fur dressing and dyeing plant. Besides a large general business in mixed pelts, the latter plant turns 35,000 muskrats per day into "Hudson seal." These tours proved to be intensely interesting.

The twenty-nine papers presented covered a wide range of subjects, most of them called forth considerable constructive discussion, and all were well received. Although the program was well filled, there was no undue crowding and the meeting held to its schedule. The moving pictures of both Martin Johnson and Arthur Young, which were features of two evenings, proved to be as remarkable as anything ever shown in their respective lines.

PROGRAM

Tuesday, April 27

1:15 p.m.

Tour through two fur establishments, under the auspices of the National Association of the Fur Industry.

8:00 p.m.

Meeting of the Board of Directors at the Explorers' Club

Wednesday, April 28

9:15 a.m.

1. Some aspects of the morphological and palaeontological history of the organ of hearing in the Cetacea. Remington Kellogg. Slides.
2. Field notes on animal behavior. W. B. Bell.
3. Notes on the food habits of the gray squirrel. J. T. Nichols.
4. The dune dwellers of Shabarak Usu. Third Asiatic Expedition. Motion pictures.

2:15 p.m.

5. Phylogenetic significance of variations in the premolars of chimpanzees and gorillas. W. K. Gregory and M. Hellman. Slides and specimens.
6. On the occurrence of *Bison latifrons* in Comanche County, Kansas. H. H. Lane. Slides.
7. What constitutes species and subspecies? Discussion led by H. E. Anthony.

4:00 p.m.

Annual business meeting of the Society

7:00 p.m.

Annual dinner of the Society

Thursday, April 29

9:15 a.m.

8. New genera of rats from the Philippines. E. H. Taylor.
9. Some adaptations to bipedality in mammals. D. G. Morton. Slides.
10. An upper Miocene rhinocerid from Kansas. H. H. Lane. Slides.
11. Phylogeny and adaptive radiation of the Macropodidae (or kangaroos). H. C. Raven. Slides and specimens.
12. Origin of the sacro-iliac attachment in mammals. H. C. Raven. Slides and specimens.
13. Origins and migrations of the subfamilies of the Proboscidea. Henry Fairfield Osborn. Slides and charts.

2:15 p.m.

14. The lemmings of Lapland. G. Clyde Fisher. Slides.
15. The European bison in Sweden. G. Clyde Fisher. Slides.
16. Fluctuations in animal life in the northwest. Ernest Thompson Seton. Slides.
17. Hibernation of some of our small mammals. Vernon Bailey. Slides.
18. Big game in the sub-Arctic of Canada. James Critchell-Bullock. Motion pictures.
19. Some early figures of American mammals. Glover M. Allen. Slides.

8:30 p.m.

20. Trailing wild animals in Africa. Martin Johnson. Motion pictures.

FRIDAY, APRIL 30

9:15 a.m.

21. Barro Colorado as a station for the study of mammals. Frank M. Chapman. Slides.
22. The introduction of game and fur-bearing mammals from state to state. Lee R. Dice.
23. Mammal damage to the Harvard Forest. R. T. Hatt. Slides.
24. Louisiana as a fur producing state and its muskrats. Stanley C. Arthur. Motion pictures.
25. Notes on the barren ground wolf and the continental arctic fox. James Critchell-Bullock.

2:15 p.m.

Symposium: Furs and fur bearing animals

26. Furs—our oldest industry—and foreign trade. W. J. Brett.
27. The fur industry and its conservation. David C. Mills.
28. Personal recollections of old-time trappers. George Bird Grinnell.
29. Fur dressing and fur dyeing. William E. Austin.
30. Modern fur farming. Frank G. Ashbrook.

Final business session

8:15 p.m.

31. The true north. Arthur Young. Motion pictures.

SATURDAY, MAY 1

11:00 a.m.

Members assembled at the American Museum and were escorted to Bronx Park, where they were guests of the New York Zoological Society at luncheon, after which they made a tour of the park under the guidance of Dr. W. T. Hornaday and other officials of the Zoological Society.

The annual dinner was followed by a tour through the new halls of the American Museum, not yet open to the public, and examination of groups and other exhibits now in course of preparation.

The symposium aroused much interest and it is believed that it will be productive of establishing more cordial and closer relations between the society and the fur industry than have heretofore obtained.

At the business meeting officers of the society were elected as listed upon the second cover page of this issue of the Journal. Doctors Stone and Jackson were appointed to represent the society upon the council of the American Association for the Advancement of Science, and Doctor Palmer as representative at the next meeting of the National Conference on Outdoor Recreation. A communication was read notifying the society of its election to membership in the Union of Biological Societies, and Doctor Osgood was appointed to represent the society in that capacity.

Resolutions of thanks were passed for the many courtesies extended to the society by the American Museum of Natural History, the local Committee on Arrangements, the Explorer's Club, the National Association of the Fur Industry, and the New York Zoological Society. In addition, the two following resolutions were adopted:

WHEREAS: through papers and discussion before the American Society of Mammalogists at its eighth stated annual meeting it is noted that various agents are at work importing from one geographic area in the United States to other areas certain species and subspecies of mammals for the purpose of restocking such areas with game or fur-bearing mammals, and

WHEREAS: such action frequently results in an unnatural mixing of species and subspecies and may result in the establishing of certain species and subspecies far outside of their natural geographic ranges: therefore be it

Resolved: that the American Society of Mammalogists deprecates such unnatural and dangerous transportation of certain species and subspecies; and be it further

Resolved: that the Committee on the Conservation of Land Mammals take whatever steps are feasible to disseminate knowledge on this subject, to bring its attention to proper authorities, endeavor to correct the practice referred to, and to make a report on the matter at the next annual meeting of the American Society of Mammalogists.

WHEREAS: it has come to the attention of the American Society of Mammalogists that the interesting large mammal fauna of Africa is rapidly being reduced in the case of many species to the point of extermination: therefore be it

Resolved: that the society looks with great concern on the continued extermination of African game; and be it further

Resolved: that the Committee on the Conservation of Land Mammals shall be authorized and directed to communicate with the African game protective societies of other nations with a view to consulting them as to what conservation measures can best be taken.

The summary of the past year's work by the Corresponding Secretary was as follows:

Names of new members acted upon, current meeting	150
Members elected by directors in December, 1925	41
Subscribers added since April 8, 1925	10
Total members and subscribers added since April 8, 1925	201

Additions to life membership class since April 8, 1925[1]	9
Present subscribers	110
Honorary member	1
Life members	30
Annual members	826
Total membership	857
Membership April 8, 1925	700
Present mailing list of the JOURNAL	895
Gross loss to JOURNAL mailing list since April 8, 1925	69
Gross gain to JOURNAL mailing list since April 8, 1925	201
Net gain to JOURNAL mailing list since April 8, 1925	132
Members lost by death since April 8, 1925[2]	4
Resignations since April 8, 1925	15
Dropped for addresses unknown	4
Dropped for nonpayment of 1923 dues	14
Delinquent 1924 dues	18
Delinquent 1925 dues (not receiving vol. 7)	44
Subscriptions cancelled since April 8, 1925	2

Announcement was made that through an agreement with The Williams & Wilkins Company, printers of the JOURNAL, a new series of MONOGRAPHS of the society has been inaugurated, the first one of which will appear at an early date.

It was decided that the 1927 meeting of the society shall be held in Philadelphia.

—A. BRAZIER HOWELL,
Corresponding Secretary.

[1] W. L. Abbott, C. E. Akeley, H. W. Atkinson, T. Barbour, H. E. Coffin, C. Frick, H. Fuguet, M. Grant, W. D. Matthew.

[2] Jose Maria Gallegos, Richard M. Hunt, John H. Sage, Donald H. Stevenson.

COMMENT AND NEWS

The South Atlantic Expedition of the Cleveland Museum of Natural History, which was financed by Mrs. Dudley S. Blossom, a trustee of the museum, returned to Charleston, South Carolina, on June 4, 1926, after more than two and a half years collecting biological specimens from the museum's three-masted exploring schooner *Blossom*, bought and especially rebuilt for the cruise. The *Blossom* left New London, Connecticut, in October, 1923, crossed the North Atlantic by way of the north edge of the Sargasso Sea, spent four and a half months collecting on all the islands and islets of the Cape Verde Archipelago, and sailed into Dakar, Senegambia, the capital of French West Africa. Although the program of the expedition called principally for a background collection of the birds of northwestern Africa to be used in a comparative study of the Cape Verde Islands collections, a side expedition in charge of W. Kenneth Cuyler and Robert H. Rockwell was sent into the Bondu country in the interior of Senegal, where several weeks were spent in collecting the larger mammals. The specimens include many which are new to American collections; among the more interesting are two species of hartebeest, roan antelope, waterbuck, Ward's and Bohor reedbucks, a big male Gambian lion, harnessed antelope, three species of duiker, jackal, and wart-hog. Following four and a half months in Africa, the *Blossom* sailed by the Cape Verde Islands and down the Atlantic to South Trinidad and the Martin Vas groups off the coast of Brazil, where biological surveys were made. Following refitting in Rio de Janeiro, Brazil, where considerable difficulty was had in finding men to replace members of the crew who could go no further because of hardships in the life on the small sailing ship, the *Blossom* circled into the South Atlantic for albatrosses and petrels, and made extensive collections on the oceanic islands of St. Helena, Ascension, Fernando Noronha, and Rocas Reef. On the way back to the United States, five days were spent studying the life in the southwestern corner of the Sargasso Sea. The expedition brought back about thirteen thousand specimens, over five thousand of which were birds; marine fishes and invertebrates form the major part of the remainder. The small collection of mammals contains interesting specimens of cowfish and porpoises from Ascension, Fernando Noronha, South Trinidad, and São Vicente Islands; and rats, mice, goats, hogs, and other descendants of animals liberated on the oceanic islands two centuries ago by the early explorers. George Finlay Simmons, leader of the expedition, has taken up his position as Curator of Ornithology in the Cleveland Museum, where, assisted by W. Kenneth Cuyler, also of the museum's scientific staff, he is arranging the collections for study.

During the early summer of 1925, Dr. S. I. Ognev, of the Zoological Museum of Moscow University, conducted an expedition into Transcaspia, where he secured four hundred specimens of mammals and many photographs. He devoted his attention chiefly to the Kopet-Dagh Mountains, a region which he reports is very beautiful and interesting.

A determined attempt is being made on the part of the officials of some of the Canadian provinces to save from extermination the few prong-horn antelopes remaining within their jurisdiction. A particularly noteworthy effect is in Saskatchewan, where it is estimsted there are less than five hundred prong-horns left. In this province, F. Bradshaw, Game Commissioner, is striving to educate and interest the people in antelope conservation and is paying special attention to the enforcement of laws protecting these animals.

Dr. William T. Hornaday, for thirty years director of the New York Zoological Park, retired on June 1. His successor is Dr. W. Reid Blair.

The State Legislature of Michigan has appropriated $900,000 for the building and an additional sum for the purchase of land for the new Museum of the University of Michigan. Progress has already been made in securing land for the site, which is in the residential district adjoining the University property. It is anticipated that actual construction work will be under way before the close of this calendar year. The departments to be cared for in the new building are the museums of zoology, geology, anthropology, and botany. The chief features of the building are to be fireproof construction; liberal space for collections, laboratories, and offices; special conveniences for investigations; and a grouping of laboratories; offices, work rooms, and study collections separate from a limited exhibition space. Plans also call for a vivarium, which should be a part of every well organized museum.

At the summer session of Columbia University, New York City, a course in museum administration is being given by Miss Laura M. Bragg, director of the Charleston Museum, Charleston, South Carolina.

On January 18, 1926, there was organized in Berlin the "Deutsche Gesellschaft für Säugetierkunde" with about one hundred and thirty members. The officers elected are Dr. Ludwig Herk, first president; Dr. Ludwig Döderlein, second president; Dr. Max Hilzheimer, third president; and Dr. Hermann Pohle, secretary. The new society plans to devote its attention to the study of mammals in a broad way, as does our own society, including such phases as taxonomy, paleontology, and psychology. It will perhaps later issue a publication. May we look forward to friendly coöperation with our sister organization.

Joseph Dixon of the Museum of Vertebrate Zoology of the University of California, with George Wright as companion, is spending the summer on a collecting trip in Alaska. A special study is being made of the smaller birds and mammals of the Mount McKinley National Park.

Dr. Charles C. Adams, formerly Director of the Roosevelt Wild Life Forest Experiment Station, Syracuse, New York, took up his new duties on May 1 as Director of the New York State Museum, Albany, New York.

The International Society for the Preservation of the Wisent, now in existence for nearly three years, held its annual meeting in Berlin, September 27 and 28,

1925. It was reported at this meeting that on January 1, 1925, there were sixty healthy wisents in Europe, besides six which were too old for breeding purposes. The Caucasian animals were not included in the count, since an accurate census of these was not obtainable. In 1922, seven calves were born; in 1923, eight; and in 1924, ten. One difficulty in the preservation of the wisent has been that the small number of animals in existence is distributed among ten different countries and fifteen individual owners. This has been overcome, in part, now that all owners are coöperating as members of the Wisent Society, and prospects for the preservation of the species are bright.

The epizoötic disease tularemia, which kills many rabbits and may act as a check in reducing the numbers of these animals, is not only carried by jack rabbits and cottontails, but also by a few species of ground squirrels, notably *Citellus mollis*. The disease is also locally known as rabbit fever or deer-fly fever and is transmitted from animal to animal by ticks and lice throughout the year. Tularemia is apparently of recent advent and probably is not directly associated with the periodic increases and decreases of rabbits and hares, so long known as characteristic with the varying hare.

Scientists of the U. S. Public Health Service have learned that tularemia may be transmitted to man by the bite of certain flies and ticks or by his coming in contact with the blood or viscera of infested animals. Cases of this disease in man have been reported from twenty-two states and the District of Columbia, but such cases are not numerous and it is not probable that the disease will ever be seriously epidemical.

Donald Harley Stevenson, reservation warden of the Biological Survey, stationed at Unalaska, Alaska, died at the Burlington Hotel, Washington, D. C., on Saturday, February 20, 1926. Mr. Stevenson had been called to Washington early in February for consultation in regard to his future work in Alaska. Soon after his arrival in the city he contracted pneumonia, from which he died after a brief illness. Interment took place at Arlington National Cemetery on Wednesday, February 24, with military honors.

Mr. Stevenson was born at Adair, Illinois, on March 31, 1892, and later moved to Montana with his parents and several brothers, all of whom survive him. He was unmarried. His connection with the Biological Survey dates back ten years, when he assisted in making scientific collections of birds and mammals, and later was a hunter in the predatory-animal control work of the bureau. In 1918 he entered the military service and was stationed at Camp Lewis, Washington, during the World War. At the end of the war he became a ranger in the Forest Service, but in 1920 was transferred to the Biological Survey and placed in charge of the Aleutian Islands Reservation.